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HOMOGENEITY TESTING OF MONTHLY TEMPERATURE SERIES

APPLICATION OF MULTIPLE-PHASE REGRESSION MODELS WITH MATHEMATICAL CHANGEPOINTS

by

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and
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ATMOSPHERIC ENVIRONMENT SERVICE

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1991

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HOMOGENEITY TESTING

OF

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A publication of the Canadian Climate Centre

ABSTRACT

A statistical method to identify inhomogeneities in monthly temperature series is presented. The method was developed as a result of homogeneity investigations that were begun in the Canadian Climate Centre (CCC) in the mid-1980s. Reports describing these earlier techniques were published as CCC Report No. 87-9 and Report No. 90-4. A principal objective of the present method was to detect inhomogeneities in the absence of some prior knowledge of the time of a site change, thereby decreasing the analyst's dependency upon the station history files. Since a large number of climate stations in Canada are relatively isolated, a second objective was that the method produce reliable results using a minimum number of surrounding stations. As well, since it has long been understood that maximum and minimum temperatures react differently to human-induced conditions, a final objective was to test these series independently.

A statistical test for detecting a change in behaviour of an annual temperature series, developed by A. Solow (1987) of the Woods Hole Oceanographic Institute, was modified and further developed by L. Vincent of the CCC, to test the homogeneity of monthly temperature series (Vincent, 1990). The method, described in this report, is based on the analysis of inconsistencies between the series being tested at the base station and a reference series produced by some surrounding stations. Regression models are used to define the relationship between these series. Parameters corresponding to inhomogeneities, and in particular, to step changes and trends, are introduced in the models and are estimated and tested for statistical significance. Residuals are also analysed to determine if the remaining variation can be better explained by another model with the addition of another inhomogeneity or changepoint.

RESUME

Une méthode statistique qui identifie des sauts et des changements de pentes dans les séries de température mensuelle est présentée. Cette méthode a été développée à partir d'investigations qui ont commencé au centre climatologique dans les années 1980 à 1990. Ces premières techniques sont décrites dans le rapport CCC no. 87-9 et dans le rapport CCC no. 90-4. L'objectif principal était de pouvoir détecter des changements dans les séries sans connaitre les évènements historiques qui auraient pu causer ces problèmes, ceci ayant pour but de diminuer l'utilisation des rapports historiques qui sont souvent incomplets. Puisqu'un grand nombre de stations climatologiques sont relativement isolées, un deuxième objectif était que la méthode puisse produire des résultats fiables en utilisant qu'un nombre minimum de stations avoisinantes. En plus, comme il est bien connu que les températures maximales et minimales réagissent différement aux facteurs antropiques, l'objectif final fut de tester ces séries séparément.

Un test statistique pour détecter un changement dans le comportement d'une série de température annuelle a été développée par A. Solow (1987) de l'institut océanographique de Woods Hole. Cette méthode a été modifiée et adaptée par L. Vincent du CCC pour tester l'homogénéité des séries de température mensuelle (Vincent, 1990). La méthode décrite dans ce rapport est basée sur l'analyse des différences entre la série testée de la station de base et une série de référence générée à partir de stations avoisinantes. Des modèles de régression sont utilisés pour décrire les relations qui existent entre ces séries. Des paramètres correspondant aux sauts et aux changements de pente sont introduits dans ces modèles, sont estimés et testés statistiquement. Les séries de résidus sont aussi analysées pour pouvoir déterminer si un autre modèle avec l'addition d'un saut ou changement de pente peut mieux expliquer le comportement de la série de base.

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1. Introduction

Canadian Climate Centre Report No. 90-4 describes an homogeneity testing method that had been adapted from the earlier work of J.M. Mitchell Jr. (see Mitchell, 1961) in the 1950s. It was based on the application of the Student's t-test, to the difference of means for five-year segments in a time series. The series, termed the difference series, was produced by subtracting a reference stations series from a base station series. Although the method performed satisfactorily it soon became apparent that some major deficiencies existed in its utility. These included the requirement for extensive manual intervention in the process to define and establish an areally representative reference series, to extract station history information from paper files, and to chart the results of the analyses. Considerable subjectivity was also necessary in analysing the various outputs. A high degree of dependence upon station history information was inherent in the process and a requirement for a large number of surrounding reference stations was unavoidable.

The overriding objective of the current method was to eliminate, as much as possible, many of the above problems. It will be seen that this new technique, does in fact, alleviate most of these. A method was sought which would be able to detect inhomogeneities without some prior knowledge of the time of a site change. This capability would greatly lessen the dependency upon the station history files, an essential requirement of most previous homogeneity testing methods (Jones et al, 1986; Karl and Williams, 1986). Such files are usually retained as paper copies only (not strictly true, as digital files often do exist) and are at best, lacking in important detail. Because of their bulk, age, and content of historical artifacts, they are often awkward to handle physically, and it is generally a laborious task to extract relevant information from these. With the current procedure, statistically significant mathematical changepoints are first identified as potential inhomogeneities. Whenever the available historical information supports these mathematical changepoints with evidence of human-induced influences on the dataset, confidence is assured that the inhomogeneities are indeed unrelated to natural climate variations. Since the historical documentation is often incomplete, however, the identification of "real" inhomogeneities is possible but verification with firm evidence as to the causes is frequently lacking.

A second major feature of the current method is its ability to perform well with a minimum number of surrounding stations needed to build an areally representative reference series. It was determined through empirical testing that four to six "good" surrounding stations are all that are required. The use of more than six reference stations does not significantly improve the resulting analyses. This attribute is a distinct advantage over previous methods, especially when applied within the Canadian context. Here in Canada, where geography is vast and climate networks sparse, we do not usually have the "luxury" of many nearby surrounding stations for preparation of a suitable reference series. In other countries, as for example, the United States, it is common to be able to utilize in excess of twenty nearby stations against which to test. Most previous testing methods were dependent upon an extensive

reference series produced from a large number of stations (Karl and Williams, 1986) and hence were difficult and often impossible to apply in some regions of this country.

The current method has also enabled the separate and independent examination of monthly and annual mean maximum and minimum temperature series. It is well understood that maximum and minimum temperatures act and react differently to various physical, human-induced stimuli and that combining them into a single mean series, masks much important detail. It is generally found, as might be expected, that minimum temperatures are more sensitive to "artificial" changes at or near an observation site and more inhomogeneities are found to exist in these. Maxima, on the other hand, are found to be generally more stable and less affected, usually exhibiting fewer inhomogeneities.

Unlike most other methods of homogeneity testing, the current method is designed, as much as possible, to be as automated and as objective as possible. To this end, it does in fact, permit relatively rapid application and quick identification of homogeneous series. If a series is determined to be homogeneous, the procedure ends abruptly and subsequent or follow-up analysis is unnecessary.

2. Purpose

The principal objective of the current work is to develop an homogeneity testing technique that is mathematically and statistically based, as objective as possible, easy to apply, and which produces reliable results with a minimum number of surrounding stations. The need for such a technique was identified and discussed at some length by Gullett et al (1990). Inhomogeneities that are to be identified by this procedure include steps, spikes, trends (greater than twenty years duration), and inhomogeneous periods (including trends of less than twenty years). Ultimately, this work will contribute to the designation of official Atmospheric Environment Service (AES) Reference Climate Stations (RCS) in Canada and to the creation of an Historical Canadian Climate Database (HCCD) comprising long-term, continuous, temperature series that will be analysed extensively in climate change detection studies for Canada, North America, and for the Northern Hemisphere. These activities are in support of the objectives of the World Climate Program (WCP) of the World Meteorological Organization (WMO).

Steps, for purposes of this work, are defined as sharp, sudden increases or decreases in the mean of the series within the temporal bounds of one data point to the next, and with some persistence of the mean before and after the discontinuity. The magnitude of the change in mean before and after a step may vary from a few tenths of a degree to several Celsius degrees. Steps are usually easily detected through visual inspection of a plotted time series. "Large" steps are most often the result of some prominent human-induced

changes at or near the observing site, specifically, and most frequently, a major relocation of the observing station with an accompanying large change in elevation and/or exposure. Figure 1.0 illustrates schematically the effect on a time series of such a step change.

Spikes are extreme values in a series that lie outside the normal variability of the series, that is, beyond two or three standard deviations from the mean. Temporally they represent single data points, either monthly or annually for our purposes, that do not "fit" with the remainder of the series and they too are easily visually recognizable. "Large" spikes tend to be most commonly related to missing data points that are not estimated or that are poorly or improperly estimated.

Trends are relatively smooth, monotonic increases or decreases in the mean of a series with time. They include both linear and nonlinear changes with time (Karl, 1985). Trends for purposes of this work are considered to be of practical or climatological significance when they involve changes of one or more Celsius degrees over a period of twenty years or more. Trends identified by the current technique are considered to be of a non-climate nature since they do not also occur at the surrounding stations. Of course, extreme caution must be exercised in assessing these trends. A change in the local climate at the observing site could produce a trend of this type, such as for example, an increase in the urban character of the local environment. Increases in urban development, buildings, industry, and other potential heat sources are probable causes. Karl reported the presence of non-climate trends, not only in large urban areas in the United States, but also in non-urban areas with populations of 50,000 or less. He and his colleagues found the presence of non-climate trends in 77 of 130 such locations studied, with an average rate of increase in monthly mean temperature of 0.09°C/10 years (Karl, 1985). In Canada, most climate stations are located in non-urban areas, however, non-climate trends are identified at a number of stations (see Appendix). In some cases they are at locations where they might be expected while in others they are completely unanticipated. Also, in some instances they are identified in one or other of the two temperature series examined, while in others they are in both. Figure 1.0 illustrates schematically the effect on a time series of an increasing trend. Decreasing trends were also found during the investigations, although their causes are usually less readily apparent.

Inhomogeneous periods are easily identified mathematically and visually, however, probable causes are often not readily apparent. They involve multiple increases or decreases in the mean of a series and often comprise multiple steps and spikes, and trends of less than twenty years duration. Multiple changes at the observing site including instrument changes, observer and observing practice changes, site relocations, and excessive vegetative growth to name only a few, are frequently responsible. Again, extreme caution must be exercised in assessing these. Documented historical evidence is critical for adequate assessment of such inhomogeneous periods and periodic site photographs are invaluable for this purpose.

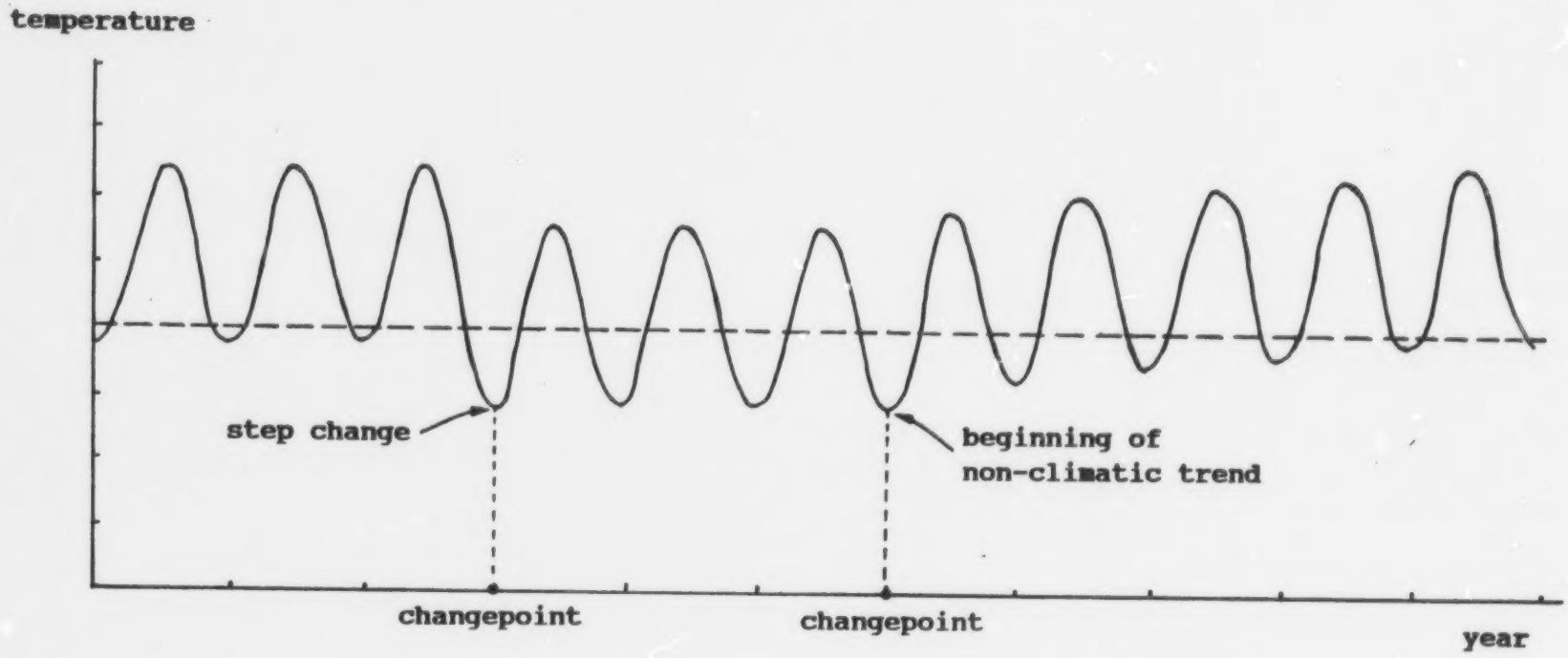

Figure 1.0 Illustration of inhomogeneities in a monthly mean temperature series.

3. Statistical Background

3.1. Two-Phase Regression Model

The method is based on the analysis of the inconsistencies between the series at the base station and a reference series produced by some surrounding stations. Regression models are used to describe the relation between these series. Inhomogeneities such as step changes and the beginnings of non-climatic trends are identified by mathematical changepoints. Since there is usually little or no prior information available about the times of change, a process for searching for changepoints in the base series is established. By fitting several multiple-phase regression models, it is possible to determine the changepoints corresponding to potential inhomogeneities.

A two-phase regression model is used to identify a single changepoint h in the base series. The dependent variable is the monthly temperature at the base station which is to be tested for homogeneity. The first independent variable corresponds to the position of each monthly value and represents the time. The monthly temperatures of some surrounding stations are introduced in the model as independent variables such that the regression line follows month by month the annual pattern corresponding to the climate of the area. For illustrative purposes, three surrounding stations are used in the following equation.

The two-phase regression model can be expressed as follows:

$$y_i = \begin{cases} a_0 + b_0 t_i + c_1 x_{1i} + d_1 x_{2i} + f_1 x_{3i} + e_i & i=1,\ldots,r \\ a_1 + b_1 t_1 + c_1 x_{1i} + d_1 x_{2i} + f_1 x_{3i} + e_i & i=r+1,\ldots n \end{cases}$$

where y_i is the temperature at the base station,
t_i is the time i=1,...,n,
x_{1i} is the temperature at a first surrounding station,
x_{2i} is the temperature at a second surrounding station,
x_{3i} is the temperature at a third surrounding station,
e_i is the random error normally distributed with mean zero and unknown variance,
and a_0, b_0, a_1, b_1, c_1, d_1, f_1 are unknown parameters.

The changepoint h is located somewhere between r and r+1. It corresponds to a change of level and/or to a change in slope occurring in the base series.
The basis of the approach is to find the maximum likelihood estimate of h, which is denoted $\hat{h}$. The likelihood function is maximized by choosing h which minimizes the residual sum of squares (SSE). Therefore, a search over all possible values of h is performed and the one providing the smallest residual

sum of squares is retained as an indication of a potential change.

3.2. Model With No Changepoint

A regression line is first fitted by the method of least squares and the corresponding residual sum of squares, SSE0, "0" for the model with no changepoint, is obtained. This regression line represents a monthly temperature series which can be considered homogeneous. The residual sum of squares is the sum of the squared deviations between each monthly value and its corresponding fitted value produced by the model. It measures the variation of the monthly values around the regression line.

3.3. Model With One Changepoint

A process to determine a single changepoint in the base series is then applied. Since the time of change is unknown, a search for the best model involving one changepoint begins. For a specific changepoint $h_1=t$, a regression model is obtained with its corresponding residual sum of squares SSE1. When this process is repeated for $h_1=2,\ldots,n-1$, a sequence of SSE1 is produced. The minimum SSE1 indicates the model with the best fit. Therefore the estimated changepoint $\hat{h}_1$ identifies a year when a potential change may occur. This process is illustrated in Figures 2.0 and 2.1.

It can be shown that the value of SSE1 produced by the model involving one changepoint is never greater than the value of SSE0 produced by the model with no changepoint. A large difference between SSE0 and SSE1 indicates that the variation of the monthly values around the regression line has been reduced substantially and that the model involving one changepoint is therefore a better representation of the behaviour of the base series. The estimated changepoint $\hat{h}_1$ provides a good indication of a change occurring in the base series. The Student's t-test is used to test for significance in the slope of the line segment before $\hat{h}_1$, for the change of level associated with $\hat{h}_1$, and for the slope of the line segment after $\hat{h}_1$. If SSE1 is not much less than SSE0 then the introduction of one changepoint in the model does not significantly improve the fit of the model with the base series.

A statistical test (F-test) is then applied to determine if the remaining variation can be better explained by use of another model with the addition of one more changepoint. The following hypotheses are considered:

H_0: there is no change
H_1: there is a change at $\hat{h}_1$

The actual test used is:

$$F^* = \frac{SSE0-SSE1}{DF0-DF1} \div \frac{SSE1}{DF1}$$

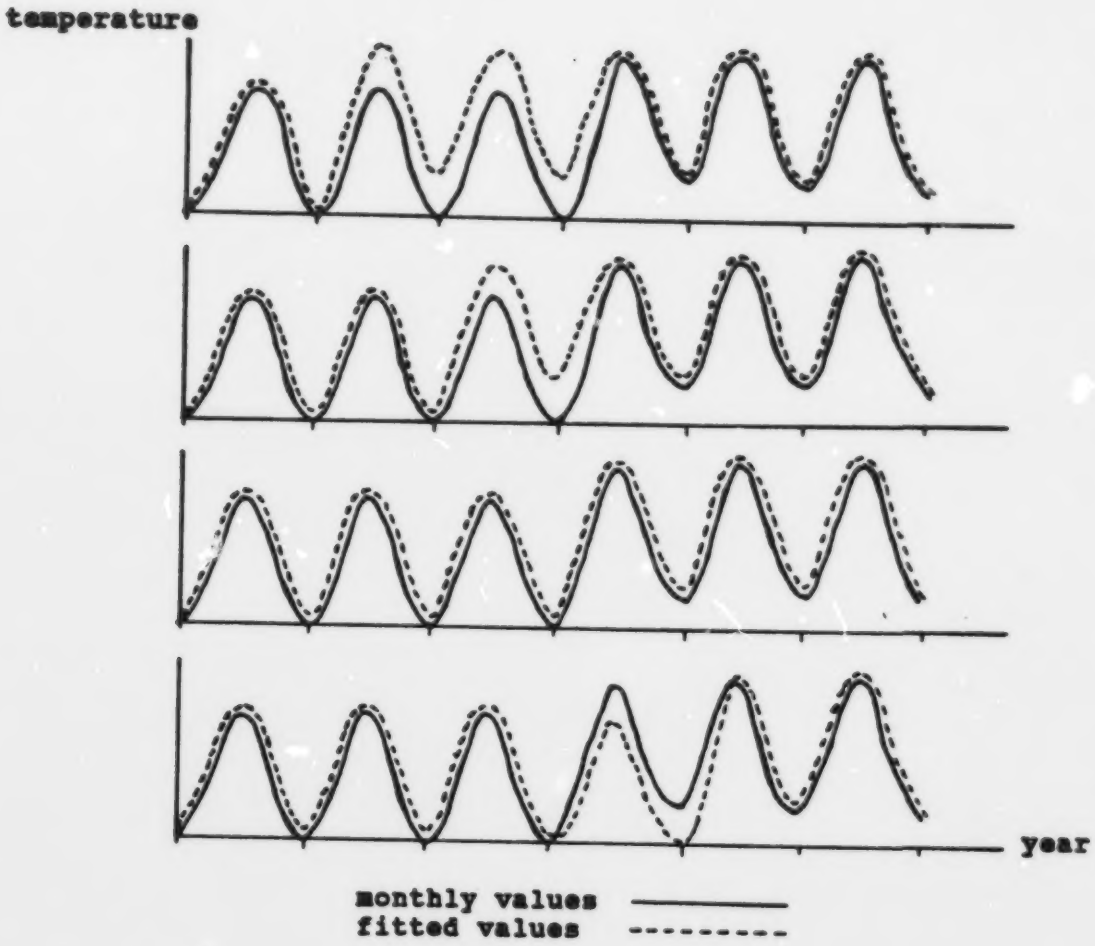

Figure 2.0 Illustration of the fit of four models with one changepoint.

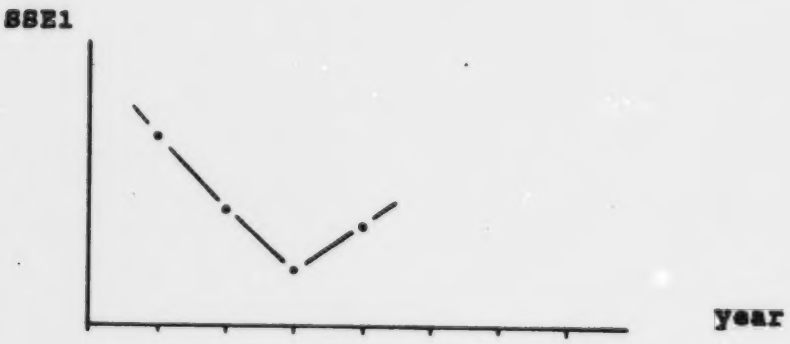

Figure 2.1 Plot of the four SSE1 in the preceding figure.

which follows approximately the F-distribution when H_0 holds. The degrees of freedom DF0 are associated with the model involving no changepoint and are equal to n-5. The degrees of freedom DF1 are associated with the model involving one changepoint and are equal to n-8. The decision rule is to reject H_0 if $F^* > F(1-\alpha;3,n-8)$. If the null hypothesis is accepted then it is concluded that the base series is homogeneous and the procedure is completed. If it is rejected then the search for the best fit model with two changepoints is carried out. Detailed information about the test is provided by Draper et al (1981).

3.4. Model With Two Changepoints

After the identification of one estimated changepoint in the base series, a search for two simultaneous changepoints is performed. A similar process is applied. For specific $h_1=t_1$ and $h_2=t_2$, a regression model is obtained with corresponding residual sum of squares SSE2. When this process is repeated for $h_1=2,\ldots,n-1$ and $h_2=2,\ldots,h_1$, a sequence of SSE2 is produced. The minimum SSE2 indicates the model with the best fit and corresponding estimated changepoints $\hat{h}_1$ and $\hat{h}_2$ identify two years in which changes may occur. The Student's t-test is applied as before to test for significance in the slope of the line segments before and after the changepoints and for the changes of level.

The F-test is used again to determine if the introduction of two changepoints in the model reduces substantially the variation of the monthly values around the regression line. If it is concluded to keep the model with one changepoint then the procedure is completed. Otherwise a search for the best model with three changepoints is then applied.

The same process can be repeated to identify more changepoints in the monthly temperature series. In fact, in the software package that was designed for operational testing purposes, the process is allowed to continue until after the best fit model with six changepoints has been selected. Along with the selection of each best fit model, the statistical significance tests are performed on the line segments before and after the changepoints and on the changepoints for changes of level. After the selection of each best fit model, the F-test is performed to determine if the model with an additional changepoint can better explain the behaviour of the base series.

4. Operational Procedure

4.1. An operational procedure was developed and an homogeneity software package (FORTRAN and SAS routines) prepared for processing on the AES Downsview mainframe computer. Application of the technique is carried out as follows:

4.1.1. Select the base station to be tested. The Climate Station Catalogue (Environment Canada, 1989) is useful in determining the date from which monthly temperature data are first available and the date from which these data are continuous. By continuous is meant that there are no periods of missing data exceeding approximately 3 consecutive years.

4.1.2. Select 4 to 6 surrounding stations which provide areally representative corresponding time series. In selecting auxiliary stations consideration is given to factors of elevation, length of record, missing data, data overlap, homogeneity, and areal representativeness. An in-house interactive software package is accessed and the following information entered: the identification number of the base station, the beginning and ending year of the period to be tested, the minimum number of years of data overlap, and the radial distance for searching around the base station. Stations within a 300 km radius of the base station and with a minimum data overlap with the base station of 85% of their periods are sought. Generally stations with large amounts of missing data (i.e., greater than 4 years) are avoided as are stations with known serious inhomogeneities. Correlations of auxiliary stations with the base station are expected to be ≥ 0.98. Stations with lower correlations with the base station are avoided if possible.

4.1.3. Run the homogeneity testing software package and obtain the printed output. A tabular listing of all input data by station is produced which includes the estimated values for the base station and the selected surrounding stations. In addition, a statistical summary table is produced summarizing the results for each regression model. The first "line" presented is the sum of squared residuals (SSE) for the model with no changepoint (SSE0). The second line shows the SSE for the best-fit model with 1 changepoint (SSE1) followed by the difference value (DIFF), that is, the difference between the previous SSE and the current SSE. A large DIFF value indicates that a significant changepoint has been introduced in the model. Next is the F-value (FVAL) which is the statistic computed in Section 3.3. Finally, the year corresponding to the estimated changepoint is shown. Subsequent lines give the same data for the model with 2 changepoints, then for 3 changepoints, and so on up to the one with 6 changepoints. A sample table is given as Figure 3.0 and a plot showing the number of changepoints as a function of the SSE values

SSE	DIFF	F	ESTIMATED CHANGEPOINTS					
SSE0= 836.8								
SSE1= 536.9	299.9	181.2	1930					
SSE2= 434.5	102.3	76.2	1931	1913				
SSE3= 416.2	18.3	14.2	1931	1913	1925			
SSE4= 403.5	12.8	10.2	1931	1913	1925	1961		
SSE5= 398.5	5.0	4.0	1931	1913	1925	1961	1937	
SSE6= 394.0	4.5	3.7	1931	1913	1925	1961	1937	1933

DIFF Threshold = MSE x 36 = 0.86 x 36 = 30.96

Figure 3.0 Summary results of the analysis for each of six models.

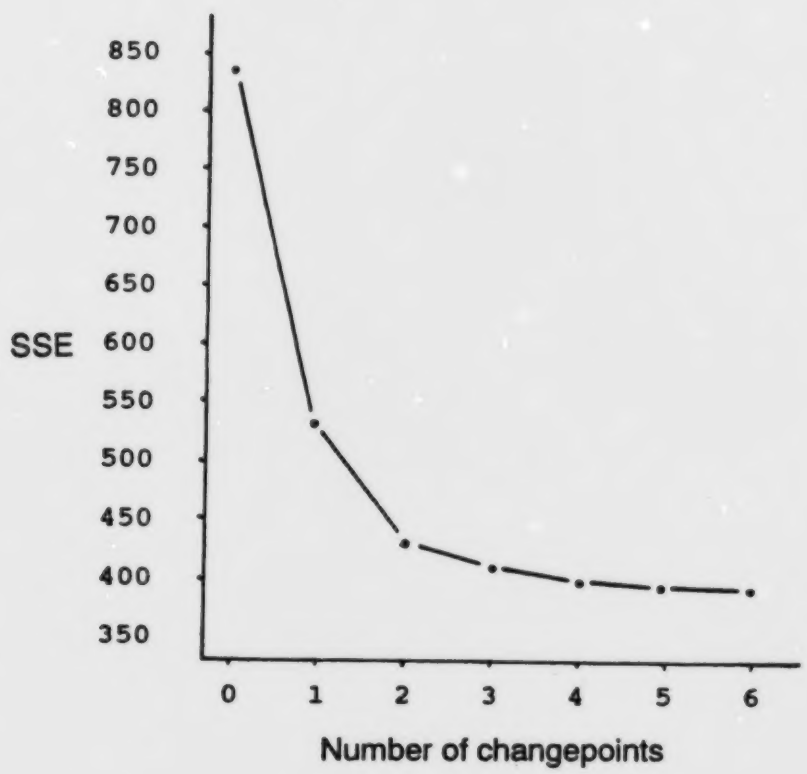

Figure 3.1 Plot of the SSE against the number of changepoints.

as Figure 3.1.

4.1.4. Search the tabular results described in the preceding section (4.1.3.) for the model with the greatest "improvement of fit", within a specified level of variability, as defined by the MSE (mean square error or error between the observed and predicted values) x 36 (3 consecutive years of 12 monthly values). It was found that for a total record length of approximately 70 years, the MSE x 36 represents a difference of up to about one Celsius degree over a period of about 20 years. The MSE x 36 value, although somewhat arbitrary, does explain an improvement in the model of at least some specified amount. The MSE value corresponding to the model with no changepoint is used as the "seed" value. Search the DIFF values in the table of Figure 3.0 for the "line" where the DIFF value drops below the MSE x 36 threshold. This identifies the model with the required amount of improvement of fit. In the example, the model with 2 changepoints is indicated and the corresponding estimated changepoints are 1931 and 1913. The procedure usually yields a clearly identified single model with mathematical changepoint(s) indicated by calendar year. If the noise level in the data is particularly high (i.e., MSE ≥ approximately 1.0) a clear indication of the best-fit model is not always available and 2 or more models may appear to show a similar fit. Such cases are relatively few and must be dealt with individually sometimes resulting in a somewhat more subjective analysis after consideration of all sources of information. If the first DIFF value is smaller than the MSE x 36 then the series is considered to be homogeneous.

4.1.5. The statistical test is designed such that all changepoints identified by the procedure are statistically significant at the 95% or higher level. The F-statistic provides an indication of whether a better fitting model might be available with the addition of another changepoint. The MSE x 36 value is used along with the F-statistic in the operational procedure as outlined above for this purpose.

4.1.6. An analysis of variance table and a parameter estimates table for each model including the one with no changepoints is also produced by the SAS statistical software package. The SSE values (sum of squared residuals), the MSE values (mean squared errors), and the P-values (probabilities) are used in the analysis. Figure 3.2 provides an example of the output table for the model with no changepoint (SSE0) and Figure 3.3, the same table, for the corresponding model with two changepoints (SSE2).

4.1.7. Use the results of the analysis of variance and of the parameter estimates tables referred to in the preceding section (4.1.4.), of the appropriate best-fit model to complete the analysis. In the example, the model with 2 changepoints is used and the results are given in Figure 3.3. The variables X1, X2, X3, X4, X5, and X6 correspond to the monthly temperature series of surrounding stations

SAS

DEP VARIABLE: TEMP

ANALYSIS OF VARIANCE

SOURCE	DF	SUM OF SQUARES		MEAN SQUARE		F VALUE	PROB>F
MODEL	7	104412.33		14916.04663		17398.258	0.0001
ERROR	976	836.75400	SSE0	0.85732991	MSE		
C TOTAL	983	105249.08					
ROOT MSE		0.9259211		R-SQUARE		0.9920	
DEP MEAN		10.26494		ADJ R-SQ		0.9920	
C.V.		9.02023					

PARAMETER ESTIMATES

VARIABLE	DF	PARAMETER ESTIMATE	STANDARD ERROR	T FOR H0: PARAMETER=0	PROB > |T|
INTERCEP	1	0.20416660	0.09058998	2.254	0.0244
*OBS	1	-0.000084107	0.000122619	-0.686	0.4929
X1	1	0.06569457	0.03561148	1.845	0.0654
X2	1	0.24615010	0.02758993	8.922	0.0001
X3	1	0.02287091	0.03170443	0.721	0.4708
X4	1	0.24598800	0.02321501	10.596	0.0001
X5	1	0.02020141	0.04270453	0.473	0.6363
X6	1	0.33772241	0.03171155	10.650	0.0001

* 1907-1988 slope = -0.00008, t = -0.686, prob = 0.4929, no significant trend

Figure 3.2 Summary of the analysis of variance and parameter estimates for the model with no changepoint (SSE0).

SAS

DEP VARIABLE: TEMP

ANALYSIS OF VARIANCE

SOURCE	DF	SUM OF SQUARES		MEAN SQUARE		F VALUE	PROB>F
MODEL	12	208497.63		17374.80205		38866.958	0.0001
ERROR	972	434.51583	SSE2	0.44703274	MSE		
U TOTAL	984	208932.15					
ROOT MSE		0.6686051		R-SQUARE		0.9979	
DEP MEAN		10.26494		ADJ R-SQ		0.9979	
C.V.		6.513483					

PARAMETER ESTIMATES

VARIABLE	DF	PARAMETER ESTIMATE	STANDARD ERROR	T FOR HO: PARAMETER=0	PROB > |T|
X1	1	0.07980655	0.02591528	3.080	0.0021
X2	1	-0.004909347	0.02171858	-0.226	0.8212
X3	1	0.13691062	0.02364294	5.791	0.0001
X4	1	0.25327633	0.01711077	14.802	0.0001
X5	1	0.13819344	0.03255335	4.245	0.0001
X6	1	0.36335722	0.02369563	15.334	0.0001
BEF0073	1	0.35768306	0.17089238	2.093	0.0366
AFT0073	1	2.29143123	0.15641055	14.650	0.0001
AFT0289	1	-1.67555366	0.09924598	-16.883	0.0001
* TBE0073	1	-0.01270114	0.003819067	-3.326	0.0009
# TAF0073	1	-0.006204672	0.000749784	-8.275	0.0001
@ TAF0289	1	0.002363331	0.000139797	16.905	0.0001

* 1907-1913 slope = -0.0127, t = -3.326, prob = 0.0009, no signif. trend
\# 1913-1931 slope = -0.0062, t = -8.275, prob = 0.0001, significant trend
@ 1931-1988 slope = 0.0024, t = 16.905, prob = 0.0001, significant trend

Figure 3.3 Summary of the analysis of variance and parameter estimates for the model with two changepoints (SSE2).

numbered 1 to 6. Changepoint 73 corresponds to the value of the seventy-third month in the series which in this case is January 1913. The variable BEF0073 corresponds to the intercept before the changepoint 73 (1913), AFT0073 is the intercept between changepoints 73 and 289 (between 1913 and 1931), and AFT0289 is the intercept after the changepoint 289 (1931). The variables TBE0073, TAF0073, and TAF0289 correspond to the trends before and after these changepoints. The P-values are used to assess the significance of the trends. For example, since the P-value corresponding to TAF0289 is 0.0001 (smaller than 0.0005), it is concluded that the trend is significantly different from zero. A "flat" line segment before and after a changepoint is indicative of a step change while a strong slope before and/or after a changepoint is indicative of either a trend, if lasting greater than 20 years, or of an inhomogeneous period, if less than 20 years in duration.

4.1.8. It is possible to plot the partial regression lines to visualize the behaviour of the base series around the changepoints. For practical reasons, however, the plot of the differences between the annual means at the base station and the annual means computed from the surrounding stations is used. Figure 3.4 shows this plot and clearly illustrates the steps identified by the changepoints in 1913 and 1931.

4.2. The above procedure enables a reasonable assessment of homogeneity with respect to steps, spikes, and trends as defined in Section 2.0 of this report. In carrying out the procedure, the analyst must bear in mind many factors relating to the evaluation of homogeneity in a time series. A number of these are outlined below.

4.2.1. Homogeneity is determined if the model with no changepoints (SSE0) has low residuals and if little or no improvement of fit is shown between this model and the model with a single changepoint (SSE1). The best fit model from all six models produced, is in this case, the model with no changepoints (SSE0). Homogeneity is also characterized by a lack of overall trends as indicated by no overall slope or a very weak overall slope that is not statistically significant. These mathematical results must also be reconciled with the plotted graphical results for final interpretation.

4.2.2. Overall trend of practical or climatological significance is characterized by a moderate to strong overall slope with an absolute t-statistic >6 identified at the 95% statistical significance level. No statistically significant changepoints are selected by the analyst when a significant overall trend is identified.

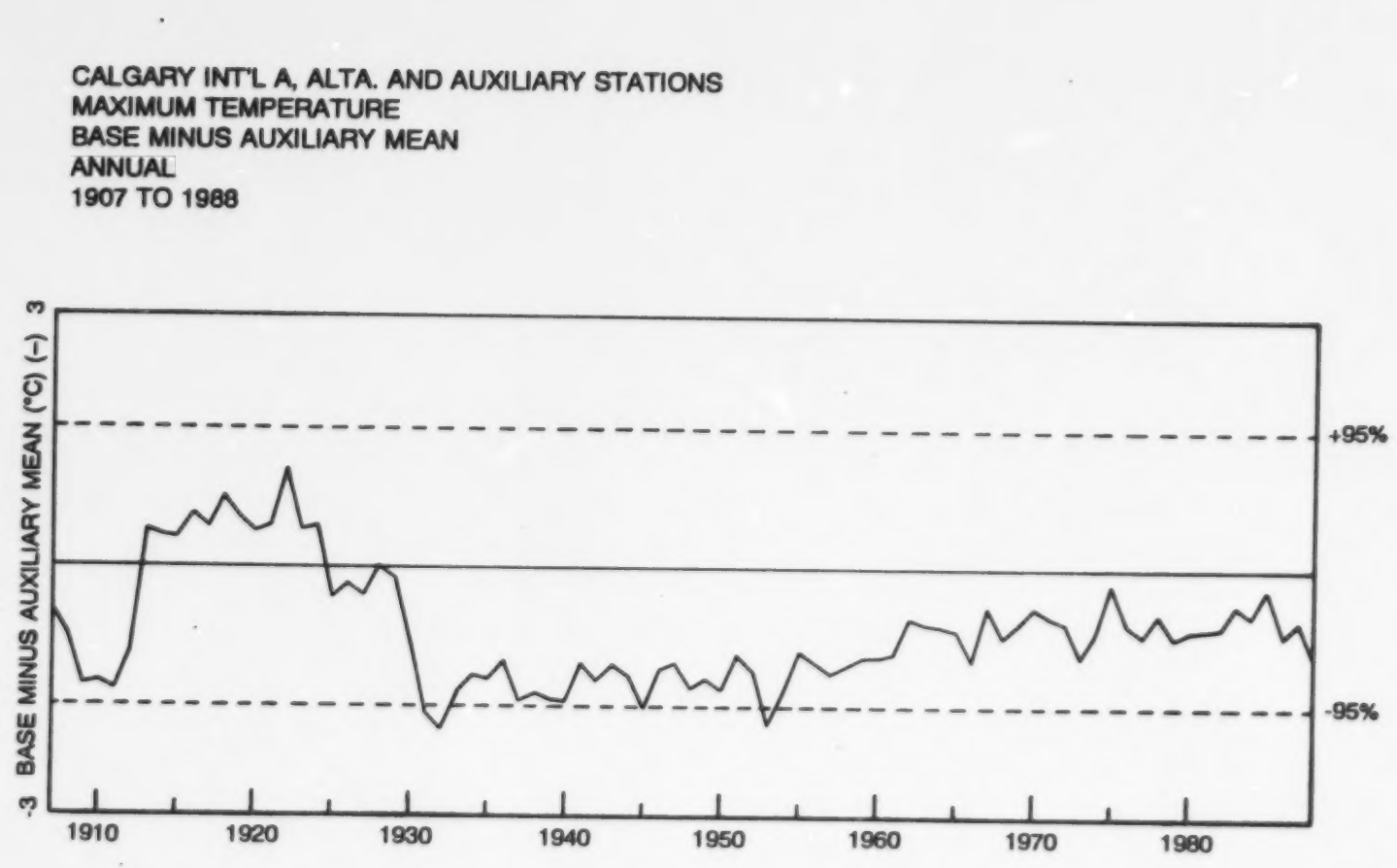

Figure 3.4 Plot of differences between the annual mean maximum temperatures at Calgary Int'l A, Alberta and at the selected surrounding stations.

4.2.3. Changepoints (i.e., changes of level or step changes) are identified at the 95% statistical significance level but should also be reconciled with the plotted graphical analysis and/or with the available historical station information for verification. This lends credence to their identification as "real" steps and/or trends and not simply as statistical changepoints relative to the specific series under examination.

4.2.4. Uncertain assessment is sometimes unavoidable. Causes are usually missing data at the base station and/or at the auxiliary stations, very high noise levels (i.e., a low signal-to-noise ratio) in the series which is indicated by an high MSE value, low correlations between auxiliary stations and the base station, and on occasion, mathematical analyses that simply do not agree with the plotted graphical analyses for unknown reasons.

5. Application

The homogeneity testing procedure is applied operationally at a number of stations within a relatively homogeneous climate region. As the process commences, it is possible that an auxiliary station with an unknown serious inhomogeneity be inadvertently introduced into the analysis. However, as the testing progresses through all stations in the region, homogeneous and inhomogeneous stations are identified and assessed, and subsequently only homogeneous stations or only the best available stations are used as auxiliaries. Occassionally an auxiliary station may have to be discarded from the analysis, another more suitable station found as a replacement, and the processing procedure repeated. Since the procedure is based on regression with weighting of auxiliary stations according to the degree to which their monthly and annual pattern matches the base station pattern, small inhomogeneities at the auxiliary stations become less critical. Every effort is made, however, to select only the best available auxiliary stations against which to assess a base station. Selection of surrounding stations is highly dependent upon number of years of data overlap with the base station, number of missing monthly values, distance from the base station, elevation, and a precursory homogeneity assessment based on any prior knowledge about the stations. The maximum temperature series for the station at Calgary Int'l A, Alberta was tested and is presented here for illustrative purposes. The series for this station is, in fact, composed of a concatenation of data series from at least two other stations in the Calgary area. It was initially selected for study since historical events (i.e., station relocations) that may have caused significant changes in the monthly temperature series were well known and abundantly documented (Skinner, 1987). Six surrounding stations were carefully selected to provide the best possible representation of the temperature climate of the region.

The period from 1907 to 1988 was analyzed. The station history file revealed several station relocations but only two of these appear to have had a significant impact on the monthly temperature series. They are a move within the town in October 1912 with an increase in elevation of about 12 metres, and a move to the airport, 2.4 km NNE of the city centre, in May 1931 with an additional increase in elevation of 22 metres.

Figure 3.0 presents the results of the homogeneity testing program. The SSE values are obtained when fitting models involving no changepoint, one changepoint, two changepoints, and so on up to six changepoints. The DIFF value is the difference between the previous and the current SSE and a large DIFF value indicates significant improvement over the previous model and suggests the introduction of a significant changepoint. The FVAL value is computed as shown in Section 3.2.2. The MSE value for the model with no changepoint is in this case 0.86 (Figures 3.0 and 3.2) and the MSE value x 36 equals 30.96. Since the DIFF value drops below the computed DIFF threshold of 30.96 in passing from the model with 2 changepoints to the model with 3 changepoints, the model with 2 changepoints is retained (underlined in Figure 3.0). Thus little additional improvement of fit is evident in the model with 3 changepoints and in subsequent models. It is always possible to investigate the model immediately following the selected best-fit model.

After the identification of the changepoints corresponding to significant changes in the base series, the program, when allowed to continue executing, identifies more changepoints, but these are often produced as a result of the lack of fit of the subsequent models. It is highly desirable therefore to include a graphic analysis and the station history report to determine if a particular changepoint corresponds to a "real" or "practically" significant change in the monthly base series which may have been generated by some human-induced activity at or near the base station. The plot of the differences between the annual means at the base station and the annual means computed from the surrounding stations is used to assist in this application (Figure 3.4).

The analysis of the maximum temperature series at Calgary shows that the station relocations in October 1912 and in May 1931 had significant impacts on the time series.

6. Homogeneity Test Results

Inhomogeneities, such as spikes, step changes, the beginning and ending of trends, and inhomogeneous periods have been identified at over 700 Canadian climate stations. These results are tabulated in the station summary of monthly and annual maximum and minimum temperatures and are given here as an Appendix. Inhomogeneities identified by the foregoing procedure are relative to an "areally-representative" series that was prepared as a result of a careful selection of nearby "reference" stations. In most cases, the complete

record for a station could not be tested because of missing values at either the base station or at the reference stations or because of a lack of suitable nearby reference stations. At the time of this work, little attempt was made to combine datasets for nearby stations, at either the base or the surrounding sites. However, future studies should involve such dataset combinations, in order to provide a larger number of long-term records than presently exist as single datasets.

The following notes describe the heading codes used in the summary tables.

D_b : date of first available temperature data
C_f : date of first available continuous temperature data (i.e., no missing data gaps exceeding 4 years)
T_f : date from which monthly temperature series were tested
T_t : date to which monthly temperature series were tested
D_e : date after which continuous temperature data were no longer available
H : all available/relevant station history information was or was not (y/n) extracted from AES station inspection records

The following notes describe the codes used to summarize the test results as shown in the accompanying tables.

nt : series was not tested for various reasons
nr : series was not tested because of a lack of suitable reference stations

H : series was found to be "homogeneous" for the period tested

S50 : series was found to contain a "spike" at 1950 (i.e., 1 or 2 years with outliers)
I25,50 : series exhibited an "inhomogeneous period" from 1925 to 1950
I50 : series exhibited a "step" change at 1950 with no historical support
I50 : series exhibited a "step" change at 1950 with historical support
I50U : series exhibited a "step" change at 1950 with some unclear historical support
T25,50 : series exhibited a "trend" from 1925 to 1950

U : test results were unclear even with suitable reference stations
P : test results were unusable because of poor reference stations

7. Discussion

The homogeneity testing of maximum and minimum temperature series described in this report represents the culmination of extensive investigations and deliberations that have been ongoing in the Climate Centre since the mid-1980s. Considerable time and effort was expended attempting to develop an effective, efficient, and more easily applied method of testing for homogeneity at a large number of temperature reporting stations. Because of the rather laborious nature of all previous techniques and the large number of stations to be tested, it was felt necessary to develop a method that could be more readily applied and that would yield reliable results more quickly. In spite of this objective, it was realized that it is not possible to eliminate entirely the dependence upon detailed station history information to properly and adequately identify and verify inhomogeneities. Unfortunately, however, station history files are frequently sadly deficient in detail and there is not much that can be reasonably done to improve the situation, either for current or past historical records.

Some general observations which have come out of this work over the past few years are of interest here. The station history files for the Atmospheric Environment Service climate observing stations, and quite probably for those of other national meteorological services too, are generally inadequate for effective assessment of data homogeneity. As a result, it was often difficult to relate analytical findings to physical causes since information contained in these history files or metafiles, as they are often referred to, was sketchy, scattered, incomplete, irregular, and not well-defined. Very often, much of the information that was contained in these files was completely irrelevant to the work, such as, for example, the names and personal data relating to early weather observers. At the time of their original preparation, there was essentially no concept of their usefulness to future climate change activities. Station history files for the most part do not extend back sufficiently into the historical past and often were begun only near the middle of this century. Such is frequently the case, even with an observational record of a hundred or more years. In addition, station inspection reports were usually done at only intervals of ten or more years. In more recent times, during the 1960s, 1970s, and 1980s station inspections have been generally more frequent and have been more oriented towards providing information that is of direct importance in determining the quality of the observations produced, such as for example, specific details of site conditions and site alterations. This more precise and detailed information is of importance in current and future analyses, but because of its short history, is of limited utility in assessing our climatic past.

Site photographs showing each quadrant of the observation area taken at five or ten year intervals have proven to be invaluable. They clearly illustrate conditions and problems that might arise or develop over time at an observing site. The old adage, "one picture is worth a thousand words", is certainly applicable here. Unfortunately, site photographs are frequently lacking entirely or are too infrequent to provide the required detail, however, when they are present they are priceless. The importance to this

work, of good, frequent, regular site photographs cannot be over-emphasized. They should be encouraged and even made a mandatory requirement of all station inspections. Similarly, good, dated station site maps and sketches with identifying structures and objects clearly marked and identified and with distances and directions clearly shown are of much value in later station data assessments..

It was observed, after numerous station examinations and assessments, that the most frequent causes of detectable, sizeable step inhomogeneities in temperature time series are major site and/or station relocations. Such relocations usually involve movement of a site up to several kilometres away from its previous location and often with an accompanying significant change in site elevation and/or exposure. Minor site changes such as the relocation of the instrument compound a few hundred metres away to a slightly improved exposure are often undetectable in the resulting monthly mean temperature time series. Other minor irregularities that, contrary to popular expectation, frequently are undetectable in the monthly and annual data series are poor instrument maintenance practices, instrument changes, poor observer practices, changes of observers, variations in times of observation, and extensive growth of surrounding vegetation, to name only a few. There are documented cases where such inconsistencies did adversely affect the resulting data, however, there are many more situations in which these potential problems appear to have had little or no effect on the resulting data series.

It was also observed, as might be expected, that minimum temperatures are far more susceptible and sensitive to site changes than are maxima. Generally, many more inhomogeneities are identified in the minimum temperature series. Minor changes in elevation, instrument sheltering and site exposures appear to have a greater impact on overnight low temperatures than on daytime high temperatures. This is not unexpected since nighttime conditions, when most minima occur, are subject to the effects of radiational cooling, cold air drainage, frost hollow situations, inversions, katabatic wind occurrences, and other local phenomena. The graphical analyses for the climate stations at Roseway, Nova Scotia; Campsie, Alberta; and Sherbrooke A, Quebec are provided as illustrative examples of some of these findings. It should be noted that these stations are operated by volunteer staff except at Sherbrooke A which has been staffed with paid observers since about 1972. Comments that follow are not intended to detract in any way from the conscientious efforts of weather observers here and elsewhere. The Service will always be indebted to these individuals for their time and dedication. It is entirely because of their work that studies such as this can occur at all.

At Roseway, Nova Scotia there are inhomogeneities during the early 1980s that are clearly identified by the statistical analysis. These are extremely obvious in the annual temperature graphs for maximum and minimum temperatures at this station (Figures 4.0 and 4.1). These can be easily and reliably attributed to a number of circumstances. At this station, the chief observer passed away in 1980, a number of observers took over the observing program at this time, no observations were carried out on weekends over several months during this period, a thermograph was later installed to enable "estimated" weekend temperature observations, thick deciduous vegetation was encroaching upon the observing site over many years and was especially thick by 1982, and

finally the observing site was relocated a few hundred metres away in mid-1983 in an effort to improve the site exposure. Incidentally, good quality, regular site photographs were included as part of a detailed station history report that made assessment at this location relatively easy. It should be noted, however, that this station is relatively short-term, having been in existence only since 1956.

Another interesting example is provided by the Campsie, Alberta station located to the northwest of Edmonton. This station is a good long-term site that has been in operation since 1912. However, the first formal station inspection report on record is dated 1957. Again, site photographs are available but detailed information is scant because of the lack of early inspection reports. The photographs are quite revealing but are not included here for ease of publication. Very thick deciduous vegetation had completely "engulfed" the thermometer enclosure by 1957 (the date of the first site photograph). At this time the Stevenson Screen was relocated a very short distance away to an only slightly improved exposure away from the base of a large deciduous tree. It remained at this site until 1971 when it was again relocated a few hundred metres away to an open field site with no significant change in elevation. It is interesting to note that in spite of the very poor early site exposure conditions, there is no apparent effect on the time series for either maximum or minimum temperatures (Figures 4.2 and 4.3). This site provides an example in which one would expect to see inhomogeneities, and yet, none are clearly evident in the resulting statistical and visual analyses.

Finally, the station located at Sherbrooke, Quebec provides a fine example of the effect of "joining" the temperature record from two very different locations. The earlier Sherbrooke data were observed at a Seminary site within the city of Sherbrooke from about 1915 until 1972. In 1962 a new station was opened at an airport location 20 kilometres northeast of the city. An accompanying elevation increase of 60 metres was also registered with the new station. Good, periodic site photographs were available which contributed significantly to the analysis. Note in Figure 4.4 that the maximum temperature series appears to be unaffected by the station relocation after 1962 while the minimum series (Figure 4.5) shows an extremely sharp downward "step" with a decrease in the series mean of about 3 Celsius degrees after the discontinuity. In this situation, the maxima appear unaffected by a major station relocation while the minima are obviously greatly affected. For this site, some effort would be made to attempt data adjustments to the earlier portion of the minimum temperature series before inclusion of the data in the Historical Canadian Climate Database (HCCD).

ROSEWAY, NS AND AUXILIARY STATIONS
MAXIMUM TEMPERATURE
BASE MINUS AUXILIARY MEAN
ANNUAL
1956 TO 1988

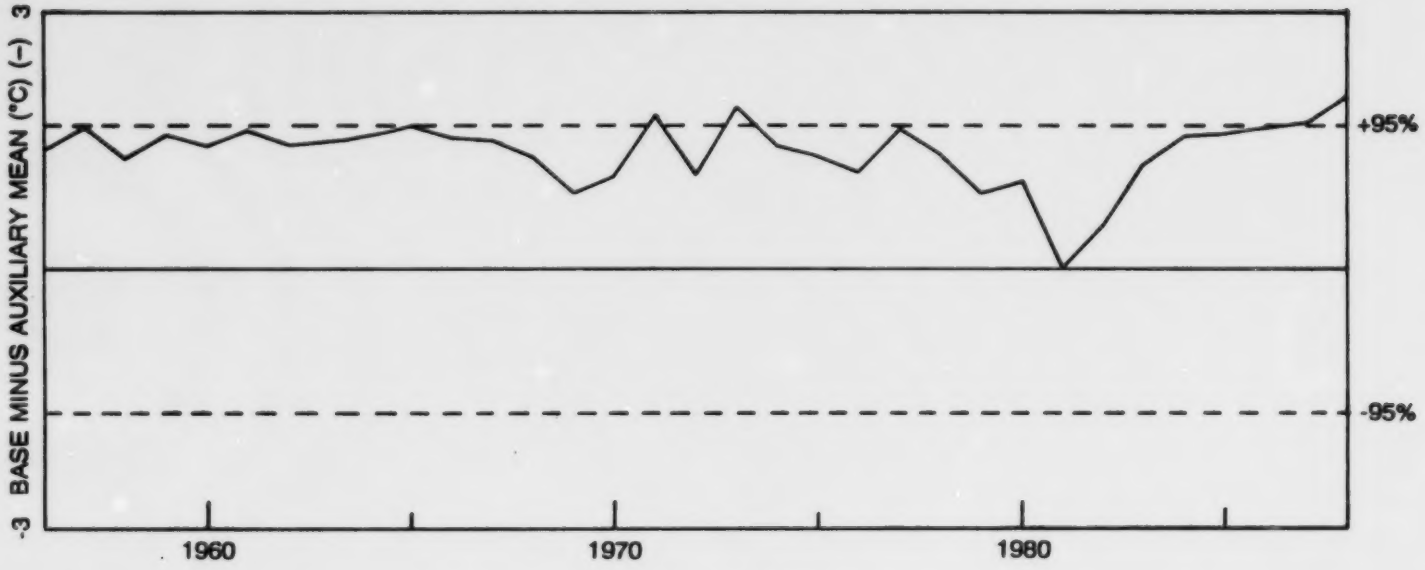

Figure 4.0 Plot of differences between the annual mean maximum temperatures at Roseway, N.S. and at the selected surrounding stations.

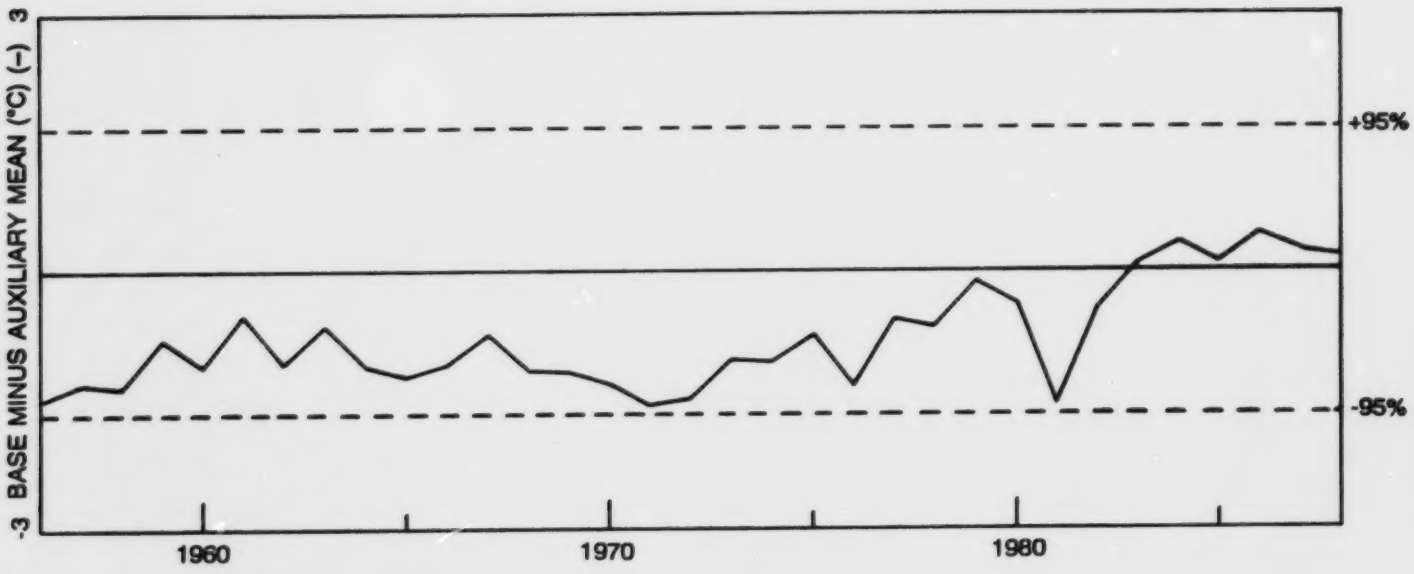

Figure 4.1 Plot of differences between the annual mean minimum temperatures at Roseway, N.S. and at the selected surrounding stations.

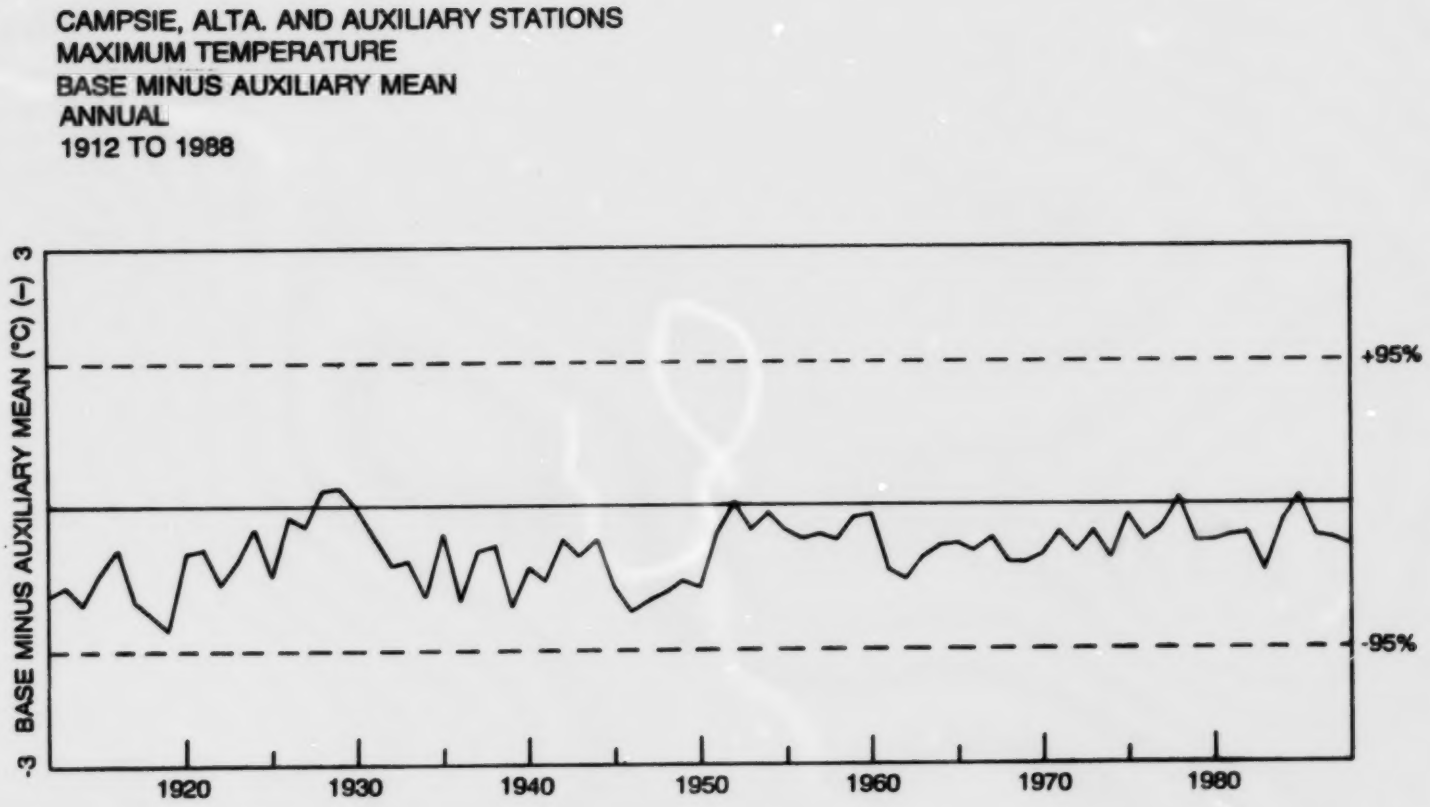

Figure 4.2 Plot of differences between the annual mean maximum temperatures at Campsie, Alberta and at the selected surrounding stations.

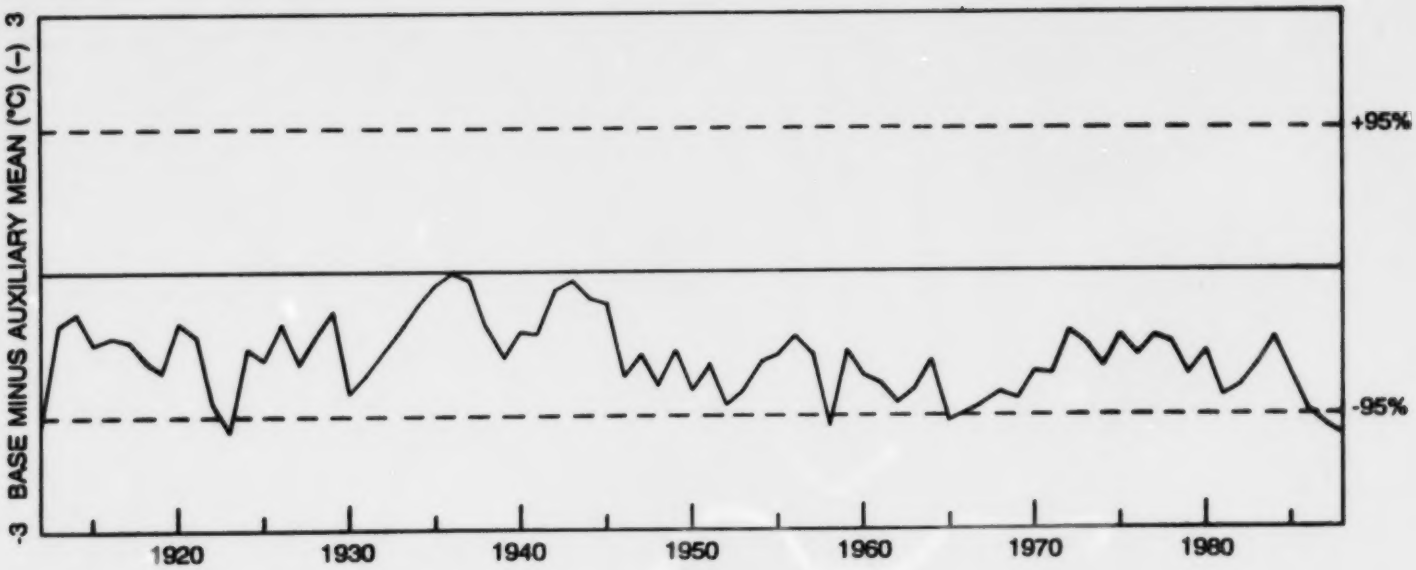

Figure 4.3 Plot of differences between the annual mean minimum temperatures at Campsie, Alberta and at the selected surrounding stations.

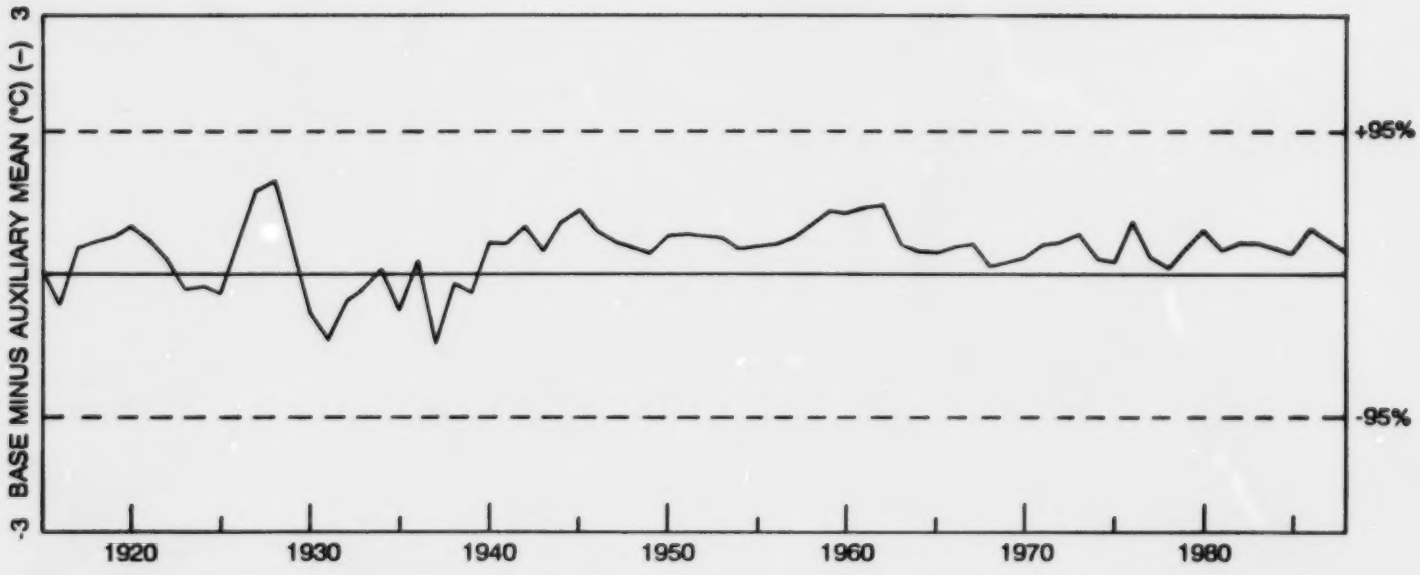

Figure 4.4 Plot of differences between the annual mean maximum temperatures at Sherbrooke A, Quebec and at the selected surrounding stations.

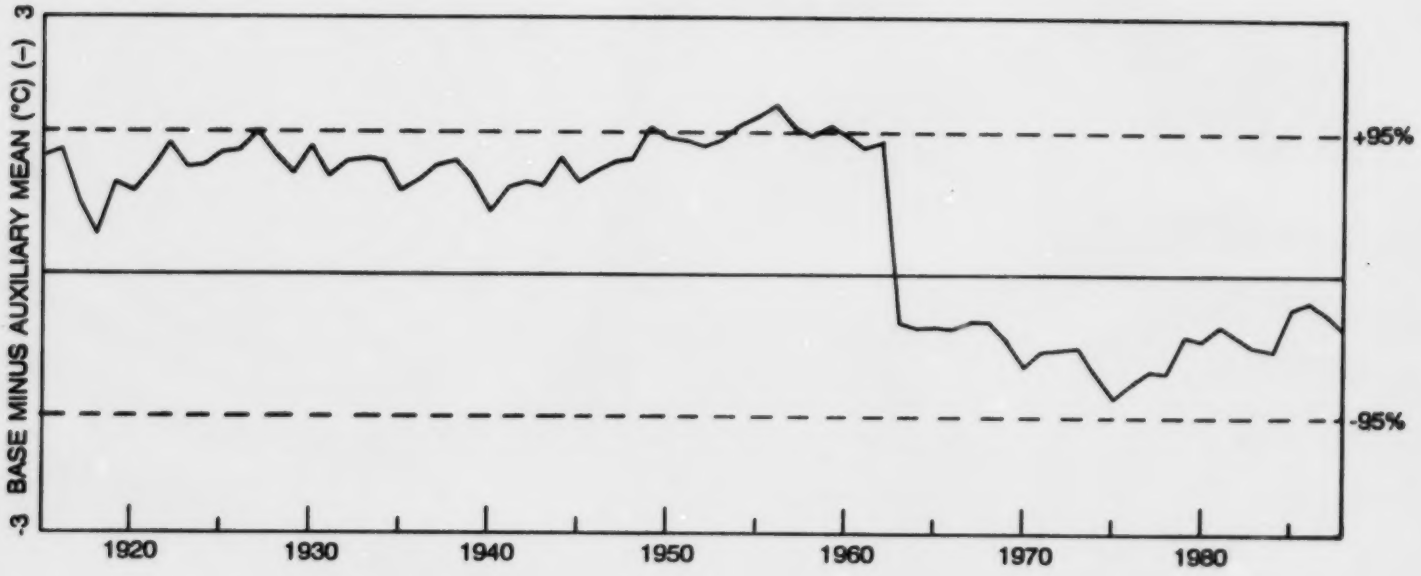

Figure 4.5 Plot of differences between the annual mean minimum temperatures at Sherbrooke A, Quebec and at the selected surrounding stations.

8. Conclusion

A recently-developed, statistically-based homogeneity testing technique was applied to monthly temperature time series at Canadian climate stations. Its application is described in this report. The reader is referred to Vincent, 1990 for an in-depth discussion of the technique and its development. It was developed specifically for application to the Canadian situation in which usually only a small number of surrounding stations are available against which to assess the homogeneity of a particular base station. The technique performs well with only minor limitations and restrictions and these are addressed in the report. The problem of homogeneity testing at truly isolated stations has not yet been resolved and it is recognized that considerable development work will be required before such a technique can be applied operationally.

The discussion on pages 19-21 of this report provides but a few examples of the many possibilities, which illustrate the kinds of irregularities and anticipated and unanticipated results obtained, during the homogeneity testing of temperature time series for Canadian climate stations. The numerous interesting and different situations relating to siting, location, and observing practices, that exist in the documented historical record at climate observing stations, warrant additional investigation and analysis. Fascinating revelations of both historical and scientific significance are contained in these documents. Each station must be dealt with separately, in great detail, and on its own merit and such work is left to other investigators with more far-reaching objectives.

The homogeneity investigations on temperature series that are described in this report have laid the groundwork for the official designation of Canadian Reference Climate Stations (RCSs). Some 254 Canadian climate stations have been so-designated at the time of writing. A number of criteria (WMO and Canadian specific) were used in the RCS station selections and homogeneity was but one of these. Work has also recently begun on the creation of the Historical Canadian Climate Database (HCCD) for use in climate change detection studies. This work has been entirely dependent upon the previous homogeneity project. The HCCD is to consist of good, long-term, reliable climate datasets that are as complete and as free of inhomogeneities as possible. Some data reconstructions and adjustments are inevitable, however, every effort will be made to minimize these. Without the previous homogeneity results, this work would be virtually impossible. It is envisioned that the HCCD with "clean", reliable; monthly, seasonal, and annual; mean maximum, minimum, and mean temperature datasets; will be available for public access within the coming months.

9. References

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Appendix

Results of Homogeneity Testing of Monthly and Annual Temperatures

Version 2.0 — April 29, 1991

British Columbia

Station Name	Station Number	Dates D_b	C_f	T_f	T_t	D_e	Maximum Series	Minimum Series	H
Abbotsford A	1100030	944	944	945	988	-	H	H	n
Agassiz CDA	1100120	889	889	940	988	-	H	I53,68	y
Alberni Rob Creek	1030230	961	961	nt		-			
Alert Bay	1020270	913	952	952	988	-	H	I77,84	n
Alexis Creek	1080289	961	961	nt		983			
Atlin	1200560	899	963	nt		-			
Babine Lake Pinkut	1070573	968	968	nt		-			
Baldonnel	1180585	927	927	942	988	-	T56,88	I56,64	y
Bamfield East	1030605	959	959	nt		-			
Barkerville	1090660	888	888	968	988	-	I75,79	I78,79	n
Barriere	1160670	955	962	nt		-			
Beatton River A	1180750	944	944	nt		967			
Bella Coola BC Hyd	1060842	961	961	nt		985			
Big Creek	1080870	893	904	nt		986			
Blue River A	1160899	969	969	nt		-			
Blue River North	1160900	946	946	nt		985			
Bonilla Island	1060902	965	965	nt		-			
Boss Mountain	1090904	967	967	nt		984			
Bull Harbour	1031110	921	921	nt		988			
Burns Lake	1091169	969	969	nt		-			
Campbell River A	1021261	965	965	nt		-			
Cape St James	1051350	944	944	950	988	-	T50,84,I84	H	n
Cape Scott	1031353	965	965	nt		-			
Cassiar	1191440	954	954	nr		-			
Castlegar A	1141455	965	965	nt		-			
Cedarvale	107ADFE	974	974	nt		-			
Chatham Point	1021480	958	958	nt		-			
Comox A	1021830	944	944	945	988	-	I47,54U	I45,52U	n
Cortes Island	1021950	947	947	952	988	-	H,S55	I52,62	n
Cowichan Bay	1012010	913	924	nt		984			
Cowichan Lake For	1012040	949	949	949	988	-	I65	T57,88	n
Cranbrook	1152090	901	909	nt		939			
Cranbrook A	1152100	938	938	nt		968			
Cranbrook A	1152102	968	968	968	988	-	H	H	n
Cranbrook A (C)	1152102	901	909	915	988	-	I15,31,I68	I15,31,T31,69U	n
Creston	1142160	912	912	940	988	-	I51,71	I40,88	n
Cultus Lake	1102220	946	962	nt		-			
Dawson Creek A	1182285	968	968	nt		-			
Dease Lake	1192340	944	944	965	988	-	H	H	n
Deer Park	1142400	955	955	956	988	-	H	H	n
Elko	1152670	952	987	nt		-			
Estevan Point	1032730	908	923	924	988	-	H	I24,54	n
Ethelda Bay	1062745	957	957	nt		-			
Fauquier	1142820	913	921	921	988	-	I21,29,S27,I44	I21,35,I35,I52	y
Fernie	1152850	913	913	nr		-			
Fort Nelson A	1192940	937	937	nr		-			
Fort St James	1092970	895	895	950	988	-	H	H	y
Fort St John	1182998	910	931	nt		945			
Fort St John A	1183000	942	942	942	988	-	I42,44,I62	I42,44,T44,74	n

Station Name	Station Number	Dates D_b	C_f	T_f	T_t	D_e	Maximum Series	Minimum Series	H
Germansen Landing	1183090	951	951	nr		-			
Glacier NP Rog Pas	1173191	965	965	nt		-			
Golden	1173210	902	902	920	988	-	P	P	y
Grand Forks	1133270	941	941	nr		-			
Hedley	1123360	904	904	940	988	-	U	U	n
Heffley Creek	1163400	953	953	953	988	-	H	I70,88U	n
Hells Gate	1113420	951	951	nt		987			
Hope A	1113540	936	936	949	988	-	H	I49,53	n
Kamloops	1163779	890	962	nt		982			
Kamloops A	1163780	951	951	951	988	-	H	H	n
Kaslo	1143900	894	912	940	988	-	I57	T45,69	n
Kelowna A	1123970	968	968	nt		-			
Kemano	1064020	951	951	955	988	-	I74,88	H	n
Kildala	1064138	966	966	nt		-			
Kitimat Townsite	1064320	954	954	nr		-			
Langara	1054500	936	936	955	988	-	H	I55,57,I65	y
MacKenzie A	1184790	971	971	nt		-			
Masset	1054920	897	897	nt		968			
McBride 4SE	1094950	922	969	nt		980			
McCulloch	1124980	936	936	nr		-			
McInnes Island	1065010	954	954	955	988	-	H	H	n
Merry Island	1045100	957	957	nt		-			
Nanaimo	1025340	892	901	nt		968			
Nanaimo A	1025370	947	947	947	988	-	I68,T68,88	T47,88	n
Nanaimo Dep Bay	1025C70	913	913	935	988	-	H	T47,71,I71	n
Ocean Falls	1065670	924	924	nt		986			
Okanagan Centre	1125700	926	926	940	988	-	H	I53,58	n
Oliver	1125760	938	938	939	988	-	I50	H	n
Oliver STP	1125766	924	955	955	988	-	H,S72	I73	n
Ootsa Lake Skins	1085835	956	956	957	988	-	I79	H	n
Pachena Point	1035940	924	924	925	988	-	H	I33,45	n
Penticton	1126145	907	907	nt		941			
Penticton A	1126150	941	941	942	988	-	I56	I61,76	n
Pine Pass Mt Lem	1186A71	974	974	nt		-			
Pitt Polder	1106180	954	954	954	988	-	H	S60,T61,88	n
Port Alberni	1036205	917	917	nt		962			
Port Alice	1036240	955	955	956	988	-	I68	I68	n
Port Hardy A	1026270	944	944	950	988	-	I58	H,S50	n
Powell River	1046390	924	924	950	988	-	H	H,S65,S73	n
Powell River A	1046391	953	953	nt		-			
Prince George	1096436	912	912	nt		945			
Prince George A	1096450	942	942	943	988	-	H	I49,59U	y
Prince Rupert	1066480	908	908	nt		963			
Prince Rupert A	1066481	962	962	nt		-			
Princeton	1126505	893	893	nt		942			
Princeton A	1126510	936	936	937	988	-	T55,77	I43,I43,60	y
Quatsino	1036570	895	895	951	988	-	I51,56	I63,I72,88	n
Quesnel	1096600	892	892	nt		970			
Quesnel A	1096630	946	946	nt		989			
Revelstoke	1176750	898	898	nt		969			
Revelstoke A	1176751	969	970	nt		-			
Revelstoke A (C)	1176751	898	898	922	988	-	I43,46	I30,38,T38,70,I70	n
Saanichton CDA	1016940	914	914	925	988	-	I40,66,I66	I53,S85	n
Salmon Arm	1166945	911	911	nt		982			
Salmon Arm 2	1166946	950	950	nt		986			
Saltspring Island	1016990	909	909	nt		977			

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Station Name	Station Number	Dates D_b	C_f	T_f	T_t	D_e	Maximum Series	Minimum Series	H
Sandspit A	1057050	945	948	956	988	-	H	I56,64	n
Shawnigan Lake	1017230	911	911	929	988	-	I29,43,T43,88	I44,T57,69,I69	n
Smithers A	1077500	942	948	955	988	-	H	H	n
Smithers CDA	1077505	938	938	nt		968			
South Slocan	1147620	940	940	941	988	-	I55U	I41,60U	n
Steveston	1107710	896	896	896	969	970	T896,51	I21,43,I43,S50	y
Stewart	1067740	910	910	nt		967			
Stewart A	1067742	974	974	nt		-			
Summerland CDA	1127800	916	916	916	988	-	I16,34,I55	T21,55,I55,67	y
Tahtsa Lake West	1087950	951	951	nr		-			
Tasu Sound	1058003	963	963	nt		984			
Tatlayoko Lake	1088010	928	928	940	988	-	I57,60,S81	I56,T62,88	n
Telegraph Creek	1208040	942	942	nt		979			
Terrace A	1068130	944	953	nr		-			
Tlell	1058190	957	957	957	988	-	I59,I72,77	I59,67	y
Tofino A	1038205	943	958	nt		-			
Topley Landing	1078209	962	962	nt		-			
Valemount	1178339	914	914	nt		975			
Vancouver Int A	1108447	937	937	943	988	-	I53	I63	y
Vancouver PMO	1108465	898	898	nt		979			
Vancouver UBC	1108487	957	957	nt		-			
Vanderhoof	1098490	916	916	nt		966			
Vavenby	1168520	913	913	950	988	-	H	H	n
Vernon	1128550	893	919	nt		960			
Vernon	1128551	971	971	nt		-			
Vernon Cold Ranch	1128580	900	900	940	988	-	I53U	I58,T58,88	n
Victoria Gonz Hts	1018610	898	898	898	988	988	T15,49	I15,29	y
Victoria Int A	1018620	940	940	941	988	-	I48,53U	I48,64U	y
Warfield	1148700	928	928	941	988	-	I41,55,S74	I45,I82,85	n
Wasa	1158730	983	983	nt		-			
Westwold	1168880	921	921	nr		-			
Williams Lake A	1098940	960	960	nt		-			
Wistaria	1088970	926	926	950	988	-	I50,55	H	n

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Alberta

Station Name	Station Number	Dates D_b	C_f	T_f	T_t	D_e	Maximum Series	Minimum Series	H
Alliance	3010160	916	953	nt		982			
Athabasca 2	3060321	958	958	959	988	-	H	H	n
Banff	3050520	887	887	937	988	-	T37,88U	I53	y
Beaverlodge CDA	3070560	915	915	943	988	-	H	H	y
Beaver Mines	3050600	935	935	935	988	-	H	I35,60U	y
Brooks AHRC	3030856	915	953	954	988	-	H	H	n
Brownfield	3010890	958	958	nt		-			
Caldwell	3031000	932	932	936	988	-	I77,88U	T47,74,I74,88	n
Calgary Int A	3031093	876	881	907	988	-	I13,31,T31,88U	I07,24	y
Calmar	3011120	915	915	916	988	-	T36,88	I58	n
Campsie	3061200	912	912	912	988	-	H	I47	n
Camrose	3011240	946	946	946	988	-	I65,S82	I65,S82	n
Cardston	3031320	918	918	940	988	-	I70,80U	I70,80U	y
Carway	3031400	914	914	915	988	-	H,S26,S37	I52	n
Claresholm Water	3031658	959	959	nt		-			
Cold Lake A	3081680	952	952	953	988	-	I53,63	I53,63	n
Coronation A	3011880	944	944	944	988	-	I44,63	I76	n
Edmonton Int A	3012205	959	959	nt		-			
Edmonton Mun A	3012208	937	937	938	988	-	T38,83	I42,I69U	n
Edmonton Nam A	3012210	944	955	nt		-			
Edson	3062240	914	916	nt		960			
Edson	3062241	960	960	nt		970			
Edson A	3062244	970	970	nt		-			
Elk Point	3012280	911	947	950	988	-	H	I50,59,T59,88	n
Entrance	3062440	917	917	968	988	-	H	I75,79	n
Fairview	3072520	931	931	942	988	-	H	I42,56	n
Foremost	3032640	915	960	nt		-			
Fort Chipewyan A	3072658	967	967	968	988	-	H,S80,S81	H,S81	n
Fort McLeod	3032680	876	895	nt		988			
Fort McMurray A	3062693	944	944	nr		-			
Fort Vermillion CDA	3072720	908	908	nt		985			
Gleichen	3032800	885	903	916	988	-	T16,38	H	n
Grande Prairie A	3072920	942	942	942	988	-	H,S42	H,S42	n
Hanna	3023000	921	921	nt		985			
High Level	3073146	970	970	nt		-			
High River	3033240	883	918	919	988	-	I19,31,T31,85	T19,88	n
Hillsdown	3023280	904	904	nt		960			
Hinton FTS	3063342	963	963	nt		980			
Jasper	3053520	926	926	nr		-			
Jasper East Gate	3063523	971	971	nt		-			
Kananaskis	3053600	939	939	939	988	-	H	I65	n
Lacombe CDA	3023720	907	907	908	988	-	I08,24,I48	T08,46,I46,73	n
Lake Louise	3053760	915	915	nr		-			
Lethbridge A	3033880	938	938	938	988	-	H	I63	n
Lethbridge CDA	3033890	908	908	914	988	-	H	T30,51,T51,88	y
Manyberries CDA	3044200	928	928	928	988	-	H,S28	I28,36	n
Medicine Hat A	3034480	883	883	911	988	-	I11,31U	T11,39,I39,48	y
Nordegg RS	3054845	962	965	966	988	-	H	H	n
Olds	3024920	914	914	914	988	-	I14,32,I64	I14,24	y

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Station Name	Station Number	Dates D_b	C_f	T_f	T_t	D_e	Maximum Series	Minimum Series	H
Peace River A	3075040	944	944	nt		-			
Pekisko	3055120	905	914	940	988	-	H	I40,59	n
Pincher Creek	3035201	960	960	nt		979			
Pincher Creek A	3035202	979	980	nt		-			
Pincher Creek A (C)	3035202	960	960	961	988	-	I77,S79	I77,S78	n
Pine Lake	3025222	960	961	nt		981			
Pine Lake (C)	3025222	904	904	904	980	981	I35,51	I35	n
Ranfurly	3015400	905	905	913	988	-	I13,26,I51	I13,29,S25	n
Red Deer A	3025480	938	938	938	988	-	U	U	y
Rocky Mtn House	3015520	945	945	nt		978			
Rocky Mtn House A	3015522	978	978	nt		-			
Rocky Mtn Hou A (C)	3015522	945	945	945	988	-	T65,88	I78	n
Sion	3015960	908	911	911	988	-	I11,50	I11,68,T68,88	n
Slave Lake A	3066001	970	970	nt		-			
Slave Lake A (C)	3066001	944	944	944	988	-	I44,46,I70,88,S81	I44,46,I70,88,S81	n
Suffield A	3036240	950	950	950	988	-	I50,71	I50,69	n
Taber	3036360	907	947	947	988	-	H	H	n
Trochu Equity	3026530	954	954	955	988	-	I65,78	H	n
Vauxhall CDA	3036681	953	983	nt		-			
Vegreville CDA	3016761	956	956	956	988	-	H,S56	H	n
Viking	3016840	923	976	nt		-			
Wagner	3066920	944	944	nt		971			
Wanham CDA EPF	3076940	961	961	962	988	-	H,S88	H,S69,S88	n
Waterton Riv Cab	3057243	966	974	nt		-			
Wetaskiwin	3017280	902	902	nt		975			
Whitecourt A	3067372	978	978	nt		-			

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Saskatchewan

Station Name	Station Number	Dates D_b	C_f	T_f	T_t	D_e	Maximum Series	Minimum Series	H
Aneroid	4020160	916	922	922	988	-	H	I22,34	y
Biggar	4040600	917	917	921	988	-	S28,T29,88	I39,I79,82,I82	y
Cameo	4051080	952	952	953	988	-	H	H	y
Carlyle	4011160	923	923	924	988	-	H	I24,57	y
Choiceland	4071560	948	948	949	988	-	H	H	n
Cree Lake 2	4061860	966	966	nt		969			
Cree Lake	4061861	969	970	nt		-			
Cree Lake (C)	4061861	966	966	967	988	-	H	H	n
Davidson	4012120	922	922	922	988	-	I34,44	S85	y
Estevan	4012390	900	900	nt		925			
Estevan A	4012400	944	944	944	988	-	H	H	y
Gravelbourg	4022960	921	928	928	988	-	H	I28,30	y
Gull Lake CDA EPF	4023060	959	959	959	988	-	H	H	y
Indian Head CDA	4013480	885	885	890	988	-	I03,I31,I46	I61	y
Island Falls	4063560	929	929	943	988	-	I43,47,I84,86	I43,46,I85,86	y
Kelliher	4013660	956	956	957	988	-	I77	I74,83U	y
Kipling	4014040	949	949	950	988	-	I50,52U	I50,52U	y
Klintonel	4024080	910	910	912	988	-	I12,34	I12,30	y
Kuroki	4014115	961	961	961	988	-	I61,76	I61,73	y
Loon Lake CDA EPF	4064600	957	957	957	988	-	I57,59	H	y
Lost River	4074640	911	911	nr		-			
Lumsden	4014720	923	923	923	988	-	I23,32,I74	I38	y
Maple Creek North	4024936	957	957	957	988	-	H	H	y
Melfort CDA	4055085	961	961	nt		-			
Midale	4015160	923	923	924	988	-	H	H	y
Moose Jaw A	4015320	943	953	953	988	-	H	I53,70	y
Moosomin	4015360	900	941	942	988	-	T51,88	H	y
Muenster	4015440	904	904	908	988	-	I23,35	I08,53	y
Nokomis	4015560	923	923	923	988	-	T23,62,I62	I23,25	y
North Battleford A	4045600	942	942	942	988	-	I42,44	I42,44,T44,88	y
Ormiston	4015680	951	951	952	988	-	H	I61	y
Outlook PFRA	4055736	952	952	954	988	-	H	I54,72	y
Oxbow	4015800	949	949	950	988	-	H	H	n
Pennant	4026040	923	923	925	988	-	H,S43	H,S28	y
Pilger	4056120	911	911	945	988	-	H	H	y
Prince Albert	4056230	884	884	nt		942			
Prince Albert A	4056240	942	942	943	988	-	H	I43,61,I70,88	y
Qu'Appelle	4016320	877	883	nt		968			
Regina A	4016560	883	898	904	988	-	I13,I32	H	y
Regina CDA	4016640	932	932	933	988	-	H,S63	I75	y
Saskatoon A	4057120	892	892	908	988	-	H	S33,I63	y
Scott CDA	4047240	911	911	911	988	-	I24,48,T48,88	I30,60	y
Semans	4017320	923	923	937	988	-	I37,45	I37,41	y
Shamrock	4027440	956	956	957	988	-	H	H	y
Shaunavon	4027480	915	915	nt		979			
Strasbourg	4017800	910	923	nt		986			
Swift Current	4028035	885	885	nt		938			
Swift Current A	4028040	938	938	938	988	-	I65U	T61,88	y
Swift Current CDA	4028060	959	959	nt		-			

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Station Name	Station Number	Dates D_b	C_f	T_f	T_t	D_e	Maximum Series	Minimum Series	H
Tugaske	4018160	923	923	923	988	-	H	T23,79,I79	y
Waseca	4048520	907	907	907	988	-	I07,26	I07,09	y
Waskesiu Lake	4068560	934	965	966	988	-	I66,75	I73,77	n
Watrous	4018640	953	953	953	988	-	H,864	I73	y
Weyburn	4018760	916	952	953	988	-	I61	I72,78	y
Whitesand Dam	4068840	938	938	nr		-			
Yellow Grass	4019040	911	911	911	988	-	H	T11,72	y
Yorkton	4019070	884	908	nt		925			
Yorkton A	4019080	941	941	941	988	-	H	I41,46,I61	y

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Manitoba

Station Name	Station Number	Dates D_b	C_f	T_f	T_t	D_e	Maximum Series	Minimum Series	H
Birtle	5010240	904	915	916	988	-	H	I54	y
Brandon A	5010480	948	948	949	988	-	I49,54	I49,54	n
Brandon CDA	5010485	890	890	915	988	-	T21,88	I54,81	y
Brochet A	5060520	948	948	949	988	-	H	H	n
Churchill A	5060600	943	943	nr		-			
Cypress River	5010640	904	948	948	988	-	H	H	n
Dauphin	5040675	890	903	nt		941			
Dauphin A	5040680	942	942	947	988	-	H	H	n
Deerwood	5020720	952	952	952	988	-	H	H	n
Emerson	5020880	877	942	942	988	-	I81	I62	n
Flin Flon	5050920	927	927	nt		-			
Flin Flon A	5050960	968	968	nt		-			
Gillam A	5061001	970	970	nt		-			
Grass River	5041140	958	958	958	988	-	H	I58,69	n
Graysville	5021160	925	925	926	988	-	I55,88	I26,64	y
Great Falls	5031200	922	922	923	988	-	I23,60	I23,62	y
Hamiota	5011240	914	927	930	988	-	H	I81	n
Indian Bay	5031320	915	915	915	988	-	H	I59,88	y
Island Lake A	5061376	970	970	nt		-			
Morden CDA	5021848	918	918	918	988	-	H	H	y
Morris	5021920	915	915	nt		987			
Niverville	5022043	961	961	nt		-			
Pierson	5012080	904	932	946	988	-	I51	I71	n
Pilot Mound PO	5022125	957	957	nt		986			
Portage La Pra A	5012320	941	952	953	988	-	H	H	n
Riding Mtn Audy	5012423	977	977	nt		-			
Russell	5012520	883	912	920	988	-	I31,56	T20,88	y
St Albans	5012540	885	885	nt		960			
Sprague	5022760	915	915	920	988	-	I20,38	I20,42	y
Stonewall	5022788	959	959	nt		-			
The Pas A	5052880	943	943	943	988	-	H	H	y
Thompson A	5062922	967	967	968	988	-	H	H	n
Winnipeg St Johns	5023243	872	872	nt		938			
Winnipeg Int A	5023222	938	938	938	988	-	H	I64	y

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Ontario

Station Name	Station Number	Dates D_b	C_f	T_f	T_t	D_e	Maximum Series	Minimum Series	H
Alton	6150243	867	867	nt		964			
Bancroft	6150465	882	882	nt		985			
Beatrice	6110605	876	876	nt		979			
Beatrice 2	6110606	979	979	nt		-			
Beatrice 2 (C)	6110606	876	876	876	988	-	T876,898,I31,I59	I24,I53,I79,I7984	n
Belleville	6150689	866	921	932	988	-	S31,S50,T51,88	T47,77,I77U	n
Big Trout Lake	6010738	939	939	950	988	-	H	H	n
Brockville PCC	6100971	965	965	966	988	-	H	H	n
Brucefield	6121025	903	903	920	988	-	H	T20,51,I51U,I82	y
Burlington TS	6151064	951	951	951	988	-	H,S73	H,S73	n
Cambridge Galt MOE	6141095	879	947	949	988	-	H	I53	n
Cameron Falls	6041109	924	924	924	988	-	I24,55	I24,39	n
Chenaux	6101494	950	950	950	988	-	H	I60U	n
Cochrane	6071712	910	910	917	988	-	I48,53	T17,88,I56	n
Cornwall	6101874	950	950	951	988	-	I51,53	I58	n
Cornwall Ont Hyd	6101901	954	954	955	988	-	H	I55,59	n
Crystal Falls	6081928	922	922	nt		988			
Delhi CDA	6131982	934	934	934	988	-	I34,67U	I67,I80,88U	n
Dryden	6032117	914	914	927	988	-	H	I32,I61,S81	n
Dunnville Pump Stn	6132148	962	962	962	988	-	H	H	n
Durham	6112171	882	947	948	988	-	H	I59	n
Ear Falls	6012198	928	950	950	988	-	H	H	n
Earlton A	6072225	938	938	939	988	-	I52U	I62	n
Fergus Shand Dam	6142400	939	939	945	988	-	H	I72	n
Fort Albany	6072460	968	968	969	988	-	U	U	n
Fort Erie	6132470	966	966	966	988	-	H	I78	n
Fort Frances	6022475	892	911	917	988	-	I17,44	I17,50	n
Gore Bay A	6092925	947	947	nt		-			
Grimsby	6133047	910	944	nt		985			
Guelph OAC	6143083	881	898	nt		973			
Haliburton A	6163156	888	888	920	988	-	I22,35	I57,T57,88	n
Hamilton RBG	6153300	950	950	950	988	-	I67,T67,88	H	n
Harrow CDA	6133360	917	917	917	988	-	T42,61U	H	n
Honey Harb Beaus	6113490	974	974	nt		-			
Hornepayne	6053570	917	917	948	988	-	U	U	n
Iroquois Falls	6073810	913	913	915	988	-	I15,48	T32,57,I82	n
Kakabeka Falls	6043930	908	908	nt		977			
Kapuskasing A	6073975	937	937	937	988	-	H	I62U	n
Kapuskasing CDA	6073960	918	918	918	988	-	I18,31,I54	T18,57,S21	y
Kemptville	6104025	928	928	939	988	-	T39,88	I39,56,I75,78	n
Kenora A	6034075	938	938	939	988	-	T39,88	H	n
Kingston Queens U	6104185	872	951	nt		957			
Kirkland Lake	6074209	941	950	950	988	-	T50,88	H	n
Kitchener	6144232	914	914	nt		977			
Lansdowne House	6014350	941	941	941	988	-	H	H	n
Leamington	6134390	916	916	nt		978			
Lindsay Filtration	6164432	969	969	nt		-			
London A	6144475	940	940	941	988	-	H	I56,88	y
Lucknow	6124700	886	886	920	988	-	H,S32	I20,75	n

Station Name	Station Number	Dates D_b	C_f	T_f	T_t	D_e	Maximum Series	Minimum Series	H
Nadawaska	6084770	915	915	916	988	-	I16,22	I16,22,I42	n
Nallorytown Landing	6104882	977	977	nt		-			
Nidhurst	6115099	947	947	952	988	-	H,S84	H	n
Nillgrove	6155183	951	951	951	988	-	H	T51,83,I83	n
Nine Centre	6025203	914	914	916	988	-	S39,I44,48	I59,S82	n
Noosonee	6075425	932	932	934	988	-	H	I62	n
Norrisburg	6105460	913	913	913	988	-	T13,51,I51,59U	I42,I65U	n
Nuskoka A	6115525	938	938	939	988	-	I81,88	I64	n
North Bay A	6085700	939	939	939	988	-	I39,41	I53,70U	n
Orono	6155854	923	923	935	988	-	T51,84U,I84,88	I71,88U	n
Ottawa CDA	6105976	889	889	915	988	-	I28	I24,I48	n
Ottawa Int A	6106000	938	938	938	988	-	H	I62	y
Owen Sound	6116128	878	878	nt		963			
Owen Sound MOE	6116132	964	964	965	988	-	H	H	n
Parry Sound	6116254	874	874	nt		976			
Pelee Island	6136335	871	871	nt		987			
Petawawa Nat For	6106400	931	931	951	988	-	H	H	n
Peterborough A	6166418	969	969	nt		-			
Pickle Lake	6016525	930	955	958	988	-	I68	I64	n
Port Dover	6136643	872	872	nt		983			
Port Stanley	6136694	871	957	nt		-			
Preston	6146711	953	953	953	988	-	H,S53	I62,S78	n
Pukaskwa Nat Park	6046770	983	983	nt		-			
Ridgetown	6137147	885	923	923	988	-	I23,60,I84,88U	T23,69,I69,88	n
Sault Ste Marie A	6057592	945	961	962	988	-	H	H	n
Sioux Lookout A	6037775	938	938	939	988	-	H	T55,63	n
Smithfield CDA	6157831	949	949	949	988	-	I62,I82,88	T61,88	n
Southampton	6127887	872	872	nt		982			
South Baymouth	6097915	954	954	954	988	-	H	H	n
Stratford MOE	6148105	959	959	nt		-			
Sudbury A	6068150	954	954	954	988	-	H	H	n
Thunder Bay A	6048261	941	941	945	988	-	H	I50,62	n
Timmins A	6078285	955	955	955	988	-	H	H	n
Tobermory Cyprus	6128323	988	988	nt		-			
Toronto	6158350	840	840	940	988	-	U	U	n
Toronto Pear Int A	6158733	938	938	nt		-			
Trenton A	6158875	935	935	940	988	-	S41,I54	I62	n
Turbine	6068980	914	914	nt		988			
Vineland Station	6139145	924	929	950	988	-	H	H	n
Wawa	6059408	940	940	nt		967			
Wawa	6059409	969	970	nt		984			
Wawa A	6059D09	976	977	nt		-			
Wawa A (C)	6059D09	940	940	940	988	-	I52	I68,I77	n
Welland	6139445	872	892	950	988	-	H	I82,88	n
White River	6059475	886	886	nt		976			
Wiarton A	6119500	947	947	948	988	-	H	I53	n
Windsor A	6139525	940	940	940	988	-	I53	H	n
Woodbridge	6159575	948	948	949	988	-	I82,88U	I82,88U	n
Woodslee CDA	6139600	946	946	947	988	-	I47,49	I83,88	n
Woodstock	6149625	870	870	940	988	-	I58	I76,82	n

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Québec

Station Name	Station Number	Dates D_b	C_f	T_f	T_t	D_e	Maximum Series	Minimum Series	H
Abercorn	7020040	950	950	nt		985			
Albanel	7060080	922	922	943	988	-	H	T43,64	n
Amos	7090120	913	913	945	988	-	I45,62	I62	y
Anticost SW Point	7050200	872	872	nt		956			
Arvida	7060320	931	931	935	988	-	H	I82	y
Bagotville A	7060400	942	942	943	988	-	I50,56U	I53,I62	y
Baie Comeau A	7040440	947	965	nt		-			
Baie St Paul	7040446	963	963	nt		-			
Barrage A Lac Kempt	7070448	913	919	nt		970			
Barrage Cabonga	7080449	929	929	nt		969			
Barrage Des Quinze	7080452	912	912	913	988	-	I13,45,I62,I74	I13,50	y
Barrage Gouin	7070454	914	914	nt		982			
Barrage Lac Morin	7050455	942	942	nt		984			
Barrage Mattawin	7070456	929	929	nt		982			
Barrage Mercier	7030457	927	927	nt		980			
Barrage Mitis	7050463	926	926	nt		966			
Barrage Temiscam	7080468	910	910	937	988	-	I37,52	T37,88	y
Beauceville	7020560	913	913	nt		985			
Belleterre	7080600	951	951	952	988	-	I68U	I68U	y
Berthierville	7010720	919	919	920	988	-	T51,88	I20,62,T62,88	y
Bonnard	7060825	961	961	nt		-			
Brome	7020840	879	968	915	988	-	I15,25,I40U	I49,T49,78	y
Bromptonville	7020860	957	957	958	988	-	H	T58,88	y
Cap Chat	7051040	934	934	nt		974			
Caplan	7051120	947	947	947	988	-	H	H	y
Cap Madeleine	7051160	939	939	945	988	-	I45,64	H	y
Causapscal	7051200	913	913	950	988	-	H	H	n
Chelsea	7031360	927	927	928	988	-	I28,30,I69	I28,30,T55,88	y
Chicoutimi	7061440	876	876	nt		979			
Coaticook	7021840	949	949	950	988	-	I50,58,S63	I50,79	y
Disraeli	7022000	908	908	950	988	-	T50,75	I86	y
Donnacona 2	7012071	952	952	953	988	-	T53,75	I64	y
Drummondville	7022160	913	913	914	988	-	I33,36	I27,36	y
East Hereford	7022300	949	949	950	988	-	H	H	n
Farnham	7022320	917	917	951	988	-	T51,63,T63,88	T51,73	n
Foret Montmorency	7042388	965	965	nt		-			
Granby	7022800	963	963	nt		-			
Grandes Bergeronnes	7042840	951	951	952	988	-	H	H	n
Grand Lac Victoria	7082880	939	939	nt		984			
Grindstone Island	7052960	871	933	nt		983			
Harrington For Far	7032997	963	963	nt		-			
Harrington Harbour	7043000	911	911	nt		978			
Hemmingford Fou Win	7023075	960	960	nt		-			
Hemon	7063090	963	963	nt		-			
High Falls	7033120	933	933	nt		972			
Huberdeau	7033160	913	913	nt		980			
Huntingdon	7023240	873	951	951	988	-	I66	I63	n
Iberville	7023270	963	963	nt		-			
Inukjuak A	7103282	921	921	nr		-			

Station Name	Station Number	Dates D_b	C_f	T_f	T_t	D_e	Maximum Series	Minimum Series	H
Isle Maligne	7063320	924	924	nt		-			
Joliette	7013360	914	914	nt		972			
Joliette Ville	7013362	967	967	nt		-			
Kénogami	7063400	921	921	nt		972			
Kuujjuaq A	7113534	917	917	nr		-			
Kuujjuarapik A	7103536	925	925	nr		-			
Labrieville Bl	7043540	955	955	nt		-			
Lac Bouchette	7063560	949	949	nt		-			
Lachute	7033650	963	963	nt		-			
Lac Mégantic 2	7023677	963	963	nt		-			
Lac Ste-Croix	7063690	958	958	nt		-			
La Malbaie	7043960	913	913	nt		-			
Lambton	7024000	915	915	nt		-			
La Pocatière CDA	7054095	899	913	913	988	-	S23,I52	I13,21	y
L'Assomption CDA	7014160	930	930	930	988	-	I63	S49,I58	n
La Tuque	7074240	911	911	920	988	-	H	I20,62	n
Lennoxville CDA	7024280	888	915	915	988	-	I22,24,I35,38	I15,78	y
Les Cèdres	7014290	913	913	913	988	-	I51	I13,67	n
Macdonald College	7024400	906	906	nt		976			
Magog	7024440	948	948	nt		-			
Manivaki	7034480	927	953	954	988	-	I61	I62	n
Manneville	7084560	949	949	nt		-			
Manouan Sanmaur	7074600	919	919	nt		972			
Milan	7024920	949	949	nt		-			
Mont Joli A	7055120	943	943	nt		-			
Mont Laurier	7035158	920	920	nt		963			
Mont Laurier	7035160	963	963	nt		-			
Mont Louis	7055200	939	939	nt		-			
Montréal Int'l A	7025250	941	941	nt		-			
Montréal Jardin Bot	7025257	948	948	nt		-			
Montréal McGill	7025280	871	871	914	988	-	I14,55	I14,48	y
Murdochville	7055380	952	952	953	988	-	I82,88	I71,I71,80	y
Natashquan A	7045400	914	914	nt		-			
Nicolet	7025440	913	913	nt		-			
Nitchequon	7095480	942	942	nt		985			
Nitchequon	7095478	983	983	nt		-			
Nominingue	7035520	913	913	nt		-			
Normandin CDA	7065640	936	936	nt		-			
Notre Dame du Laus	7035680	929	929	nt		-			
Oka	7015730	937	937	nt		-			
Péribonca	7065960	951	951	nt		-			
Philipsburg	7026040	950	950	nt		-			
Portage Des Roches	7066080	926	926	nt		984			
Port Daniel	7056120	927	927	nt		-			
Price	7056240	931	931	nt		985			
Québec	7016280	872	872	nt		959			
Québec A	7016294	943	943	943	988	-	I43,47	I61,I83	y
Rapide Blanc	7076360	931	931	nt		975			
Rimouski	7056480	869	952	nt		-			
Rivière Bleue	7056600	950	950	nt		-			
Roberval A	7066685	957	957	nt		-			
Ste-Agathe-Des-Monts	7036762	966	966	nt		-			
St-Alban	7016800	949	949	nt		-			
St-Ambroise	7066820	954	954	nt		-			
Ste-Anne-de-Pérade	7016840	949	949	nt		-			
Ste-Clothilde CDA	7027040	937	937	nt		-			

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Station Name	Station Number	Dates D_b	C_f	T_f	T_t	D_e	Maximum Series	Minimum Series	H
St-Come	7017080	950	950	nt		-			
St-Elzear de Bon	7057160	948	948	nt		-			
St-Ephrem	7027200	929	929	nt		-			
St-Féréol	7047250	915	915	nt		983			
Ste-Geneviève	7027280	952	952	nt		-			
St-Hubert A	7027320	928	949	nt		-			
St-Jérôme	7037400	932	932	nt		-			
St-Malo d'Aukland	7027520	949	949	nt		-			
St-Pamphile	7057600	950	950	nt		-			
Ste-Rose-Dégelis	7057720	932	932	nt		-			
St-Tite	7017760	920	920	nt		985			
St-Urbain	7047770	934	957	nt		-			
Schefferville A	7117825	948	948	968	988	-	H	H	n
Scott	7027840	950	950	nt		-			
Sept-Iles A	7047910	944	944	945	988	-	H,S55	I77,88	n
Shawinigan	7018000	902	902	nt		-			
Sherbrooke	7028120	900	900	nt		972			
Sherbrooke A	7028124	962	962	963	988	-	H	I85	n
Sherbrooke A (C)	7028124	900	900	915	988	-	I27,32	I63	n
Shipshaw	7068160	943	943	nt		-			
Sorel	7028200	914	914	nt		-			
Stanstead	7028280	948	948	nt		-			
Sutton	7028292	978	978	nt		-			
Tadoussac	7048320	913	913	nt		-			
Trinité des Monts	7058520	951	951	nt		-			
Trois-Pistoles	7058560	951	951	nt		-			
Trois-Rivières	7018564	934	934	nt		986			
Val d'Or A	7098600	951	951	nt		-			
Valleyfield	7028680	952	952	952	988	-	H	H,S57,S88	n
Ville-Marie	7088760	913	913	nt		-			

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New Brunswick

Station Name	Station Number	Dates D_b	C_f	T_f	T_t	D_e	Maximum Series	Minimum Series	H
Acadia Forest Exp	8100100	955	955	955	988	-	H	I55,62	y
Alma	8100200	950	950	950	988	-	H	I69,75	y
Aroostook	8100300	929	929	947	988	-	T47,68,I80	H	y
Bathurst	8100502	972	972	nt		-			
Charlo A	8100880	966	966	967	988	-	H	I74	n
Chatham	8100990	873	873	nt		947			
Chatham A	8101000	943	943	943	988	-	I64	I52,62	y
Doaktown	8101200	934	952	953	988	-	I53,62	I53,62	y
Edmunston Fraser Co	8101301	949	949	nt		979			
Edmunston	810JL00	979	980	nt		983			
Edmunston	810AL00	983	984	nt		-			
Edmunston (C)	810AL00	949	949	950	988	-	T50,83	I61,S82	n
Fredericton A	8101500	951	951	951	988	-	I79,88U	I51,61U	y
Fredericton CDA	8101600	913	913	914	988	-	I14,24	T14,36	y
Fredericton UNB	8101700	871	871	nt		952			
Gagetown 2	8101800	897	923	924	988	-	H,S50	I24,30,I63,I76	y
Kouchibouguac	8102325	972	972	nt		-			
Little River Mine	8102350	956	956	nt		988			
Minto	8103000	933	953	954	988	-	I59	I54,62,I82	y
Moncton	8103100	881	898	898	988	-	I10	T30,66	y
Moncton A	8103200	939	939	940	988	-	I43,57	I40,43,T62,88	y
Nepisiguit Falls	8103500	922	922	923	988	-	I49,64	I38,T51,88	y
Oromocto	8103800	957	957	958	988	-	H	I65	y
Rexton	8104400	924	924	925	988	-	H,S53,S56	I25,31,T47,88	y
St George	8104700	919	919	nt		981			
Saint John	8104800	871	871	nt		970			
Saint John A	8104900	946	946	947	988	-	H	I47,52,I62	y
Sussex	8105200	897	897	898	988	-	I898,51	I898,50	y
Woodstock	8105600	886	975	nt		-			

Results of Homogeneity Testing of Monthly and Annual Temperatures

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Prince Edward Island

Station Name	Station Number	Dates D_b	C_f	T_f	T_t	D_e	Maximum Series	Minimum Series	H
Charlottetown	8300296	977	977	nt		-			
Charlottetown A	8300300	943	943	943	988	-	I66	T43,77	y
Charlottetown CDA	8300400	910	910	911	988	-	I30,I58	T11,49,I61	y
O'Leary	8300525	960	960	nt		-			
Summerside A	8300700	941	941	942	988	-	S48,I49,64	H,S48	y

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Nova Scotia

Station Name	Station Number	Dates D_b	C_f	T_f	T_t	D_e	Maximum Series	Minimum Series	H
Annapolis Royal	8200100	914	914	nt		978			
Baddeck	8200300	874	935	935	988	-	I35,48	I41,52,I59U	y
Bridgewater	8200600	961	961	nt		-			
Cape Sable	8200700	948	953	nt		986			
Cheticamp	8200825	956	956	nt		-			
Clarence	8200860	958	958	nt		-			
Collegeville	8201000	916	916	916	988	-	I32,I46	I33,56	y
Deming	8201410	956	956	957	988	-	H	H	y
Digby	8201600	914	914	nt		965			
Digby Prim Point	8201605	965	965	nt		985			
Ecum Secum	8201700	940	940	nt		986			
Greenwood A	8202000	942	942	943	988	-	I58	I62	y
Halifax	8202198	871	871	nt		933			
Halifax	8202200	939	939	nt		974			
Halifax Int A	8202250	953	960	961	988	-	H	H	n
Ingonish Beach	8202500	950	950	951	988	-	H	T51,76	y
Kejimkujik Park	8202590	966	966	966	988	-	H	I72	n
Kentville CDA	8202800	913	913	913	988	-	I53	I46,I60	y
Liverpool Big Falls	8203100	940	940	940	988	-	T40,81U	I40,42,S50,I67	y
Louisburg	8203161	972	972	nt		-			
Meteghan River	8203500	937	937	nt		986			
Mount Uniake	8203600	920	920	921	988	-	H	I21,38	y
Nappan CDA	8203700	913	913	914	988	-	I63	I34,I49,T49,88	y
Parrsboro	8204400	897	897	897	988	-	I897,59,I59	I897,88U	y
Pleasant Bay Gra	8204450	955	955	956	988	-	H	H	y
Port Hastings	8204480	875	959	nt		-			
Port Hood	8204500	950	961	nt		988			
Roseway	8204600	955	955	956	988	-	I81,84	I70,88	y
Sable Island	8204700	891	891	nr		-			
St Margaret's Bay	8204800	922	922	922	988	-	T22,42	T54,88	y
Salmon Hole	8205000	938	938	939	988	-	I67,81	I39,48U,I79,88U	y
Shearwater A	8205090	944	944	944	988	-	H	I61	y
Springfield	8205200	920	920	921	988	-	I31	I21,31	y
Sydney	8205698	870	870	nt		941			
Sydney A	8205700	941	941	941	988	-	H	I41,58U	y
Truro	8205990	960	960	961	988	-	I77,I87	H	n
Upper Stewiake	8206200	915	915	916	988	-	I16,44	I16,46	y
Westphal	8206250	955	956	956	988	-	H	H,S58,S74	y
Whitehead	8206300	883	883	nt		961			
Windsor Kings Coll	8206410	872	903	nt		948			
Wolfville	8206440	870	898	nt		949			
Yarmouth	8206490	870	879	nt		941			
Yarmouth A	8206500	940	940	940	988	-	H	I52	y

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Newfoundland

Station Name	Station Number	Dates D_b	C_f	T_f	T_t	D_e	Maximum Series	Minimum Series	H
Baie Verte	8400350	958	958	959	988	-	S77	H	n
Bay D'Espoir Gn St	8400413	967	967	968	988	-	H	H	n
Belle Isle	8500500	871	871	nt		970			
Bonavista	8400600	934	956	957	988	-	H	H	y
Burgeo	8400798	966	966	967	988	-	H	H	n
Cartwright	8501100	934	934	nr		-			
Colinet	8401200	938	938	939	988	-	H	T39,88	y
Corner Brook	8401300	933	933	945	988	-	I33,55	I33,55	y
Daniels Harbour	8401400	946	946	947	988	-	I63	H	y
Deer Lake	8401500	933	933	933	988	-	I55	I33,37	y
Deer Lake A	8401501	965	965	nt		-			
Exploits Dam	8401550	956	956	957	988	-	H	H	y
Gander Int A	8401700	937	937	937	988	-	H	I62	y
Goose A	8501900	941	941	950	988	-	H	H	y
Grand Falls	8402050	934	956	957	988	-	H	H	y
Hopedale	8502400	942	942	nt		984			
Port Aux Basques	8402975	909	955	956	988	-	H	H	y
Rattling Brk Norris	8403085	959	959	nt		-			
St Johns	8403500	874	948	nt		956			
St Johns A	8403506	942	942	942	988	-	H	I77	y
St Johns West CDA	8403600	950	950	951	988	-	H	T51,78	y
Stephenville A	8403800	942	942	942	988	-	I42,48,I63,66	I51,I67	y
Terra Nova NP HQ	8403852	962	964	962	988	-	U	U	n
Wabush Lake A	8504175	960	960	968	988	-	H	H	n
Woody Point (Gr Mn)	8404320	971	971	nt		-			

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Station Name	Station Number	Dates D_b	C_f	T_f	T_t	D_e	Maximum Series	Minimum Series	H
Aklavik A	2200100	926	980	nr		-			
Alert	2400300	950	950	nr		-			
Baker Lake A	2300500	934	946	nr		-			
Broughton Island	2400570	957	957	nt		-			
Byron Bay A	3500595	957	957	nt		-			
Cambridge Bay A	2500600	929	929	958	988	-	H	H	n
Cape Dyer A	2400654	959	959	nt		-			
Cape Hooper	2400660	957	957	nt		-			
Cape Parry A	2200675	955	957	957	988	-	H	H	n
Cape Young A	2200690	957	957	nt		-			
Clinton Point	2200750	957	957	nt		-			
Clyde A	2400800	933	946	958	988	-	I84,88	I70,I86	n
Coppermine	2209000	930	932	nt		977			
Coppermine A	2200902	977	978	nt		-			
Coppermine A (C)	2200902	930	932	958	988	-	H	H	n
Coral Harbour A	2301000	933	945	nr		-			
Dewar Lakes	2401030	958	958	nt		-			
Eureka	2401200	947	947	nr		-			
Fort Good Hope A	2201400	944	944	945	988	-	I62,I81,88	I79,88	y
Fort Liard A	2201575	973	973	974	988	-	U	U	n
Fort McPherson A	2201601	981	981	982	988	-	U	U	n
Fort Providence	2201800	943	943	945	961	-	H	I45,46	n
Fort Reliance	2201900	948	948	949	988	-	H	H	n
Fort Resolution A	2202000	930	943	947	988	-	I70,88U	I68,88	y
Fort Simpson	2202100	875	895	943	963	963	H	H	n
Fort Simpson A	2202101	943	963	964	988	-	H	H	n
Fort Smith A	2202200	943	943	944	988	-	H	H	n
Gladman Point A	2402340	957	957	nt		-			
Hall Beach A	2402350	957	957	957	988	-	H	H	n
Hay River	2202398	893	893	nt		943			
Hay River A	2202400	943	943	944	988	-	H	H	n
Inuvik A	2202570	957	957	957	988	-	H	I57,69	y
Iqaluit A	2402590	946	946	nr		-			
Isachsen	2502600	948	948	nt		978			
Jenny Lind Island A	3302650	957	957	nt		-			
Lady Franklin Point	2202680	957	957	nt		-			
Longstaff Bluff	2402684	957	957	nt		-			
Mackar Inlet	2402686	957	957	nt		-			
Mould Bay A	2502700	948	948	nr		-			
Nicholson Peninsula	2202750	957	957	nt		-			
Norman Wells A	2202800	943	943	nr		-			
Nottingham Island	2402900	927	927	nt		970			
Pangnirtung	2403050	925	977	nt		981			
Pangnirtung A	2403053	983	983	nt		-			
Pelly Bay	2303090	957	957	nt		-			
Resolute A	2403500	947	947	nr		-			
Sachs Harbour A	2503650	955	955	958	988	-	H	H	n
Shepherd Bay	2303685	957	957	nt		-			
Snare Rapids	2203700	947	947	nt		975			
Tuktoyaktuk	2203910	957	957	958	988	-	H	H	n
Tuktoyaktuk A	2203912	970	973	974	988		H	H	n

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Station Name	Station Number	Dates D_b	C_f	T_f	T_t	D_e	Maximum Series	Minimum Series	H
Tungsten	2203922	966	966	nr		-			
Wrigley A	2204000	943	943	944	988	-	P	P	n
Yellowknife A	2204100	942	942	944	988	-	H	H	n
Yellowknife Hydro	2204200	943	943	943	988	-	I86,88	I43,66	y

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Yukon

Station Name	Station Number	Dates D_b	C_f	T_f	T_t	D_e	Maximum Series	Minimum Series	H
Dawson	2100400	897	897	nt		979			
Dawson A	2100402	976	976	nt		-			
Dawson A (C)	2100402	897	897	950	988	-	I50,59	I76	n
Faro A	2100517	977	978	nt		-			
Haines Junction	2100630	944	944	nt		985			
Haines Junc YTG	2100631	985	985	nt		-			
Haines Junc YTG (C)	2100631	944	944	950	988	-	H	I79,88	n
Komakuk Beach A	2100685	958	958	959	988	-	U	I73U	y
Mayo A	2100700	924	924	950	988	-	H	U	n
Old Crow A	2100800	951	968	nr		-			
Pelly Ranch	2100880	898	951	955	988	-	H	H	n
Shingle Point A	2100950	957	957	958	988	-	U	H	y
Swift River	2101081	966	965	967	988	-	H	I86	n
Teslin A	2101100	943	943	944	988	-	U	U	n
Tuchitua	2101135	967	967	967	988	-	U	U	n
Watson Lake A	2101200	938	938	945	988	-	H	H	n
Whitehorse A	2101300	942	942	955	988	-	H	I55,72	n
Whitehorse River	2101400	959	959	959	988	-	I59,61	I59,72	n